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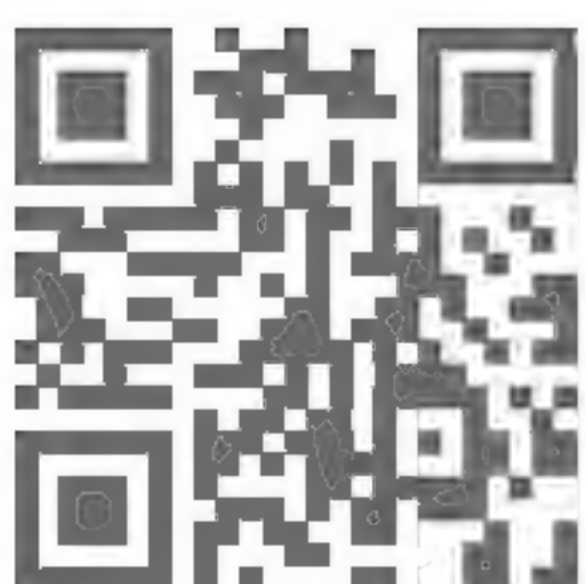


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Thriftily, sparingly, and even economical are words that have, until recently, never really been associated with the US military. It has tended to get what its services want, although perhaps not in the numbers some of them have wanted. However, the USAF is now finding itself in a position where, as laid out before it, there are some incredible future aircraft platforms in terms of performance and offensive capabilities, all of which look set to be game-changing air assets over the battlefield, according to air force strategists and the OEMs.

But here lies the problem: all are tremendously costly, and the US is still enduring the ever-spiralling costs and upgrade issues with the F-35 Lightning II, for which it plans to acquire a total of 2,456 examples, so committing itself to a delivery schedule through to at least 2044. After that, the type will remain in service until mid-2080, and who knows what upgrade costs per airframe will be by then?

However, critics of the F-35 have stated that the type is unsuitable in a future peer-on-peer contested air environment, something the US has not fought in since the first few weeks of the 1991 Gulf War. Many military analysts believe that the threat of a war with a near-peer adversary will likely occur in the next decade and that the USAF has to change how it acquires new aircraft, particularly fighters, fundamentally. The current debate within the higher echelons of the USAF regarding the fate of the sixth-generation NGAD fighter is already taking place, with a cheaper redesign of the platform currently being discussed.

But is there a solution to the decades of complex procurement procedures the USAF follows? These often result in platforms staying in service once they have 'passed their prime', leaving them to undergo countless costly upgrades that don't always run to schedule or budget.

General David W Allvin, Air Force Chief of Staff, is advocating for a new acquisition process that could revolutionise the USAF's approach to fighter aircraft. His proposal involves the purchase of adaptable, low-cost



fighters every ten years, supported by a modular design system. This system, serving as the platform's core for ongoing generations, allows for the seamless integration of new technologies over the years, while preserving the fighter's core structure and existing systems where necessary. The potential benefits of this approach are significant, promising a potent platform that can be upgraded at a fraction of the current cost.

The potential of the USAF to operate purpose-built fighters tailored to the

threats and challenges of their day would be significant. When the need to meet new threats arises, these modular fighters allow new upgrades and systems to be introduced. Known as the USAF's 'lightweight fighter concept', the idea may seem too good to be true. However, who'll say no if there's the potential to have a potent platform that can be upgraded at a significantly reduced cost?



Glenn Sands
Editor

TOP:

General David W Allvin, US Air Force Chief of Staff, proposes a new approach to how America fields new fighters, removing the 'built to last' approach in favour of a new 'built to adapt' through modular design concepts

USAF

FRONT COVER:

As an evolution of the highly successful Lynx, the AW159 Wildcat provides new technology and capability to enhance operations across maritime and land domains

Leonardo



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Cutting-edge and cost-cutting composite *fighter for*



Scaled Composites, a subsidiary of Northrop Grumman, conducted the first flight of its Model 437 Vanguard from the Mojave Air and Space Port in California on August 29. A conceptual design based on the Model 401, which was first seen in 2017, the Vanguard is, according to Scale Composites, “exploring a multi-mission low-cost attritable aircraft” concept. The Vanguard is a crewed variant of the proposed unmanned Model 437, intended to operate alongside manned aircraft in what has been termed a ‘collaborative combat aircraft’ (CCA) or ‘loyal wingman’ style scenario, depending on who you ask. Currently, the USAF is exploring this concept as part of its Skyborg programme and the RAF is seeking a similar capability in the future under a programme it calls Project Mosquito.

Scaled Composites and Northrop Grumman view the Model 437 as more than another experimental aircraft to develop into a viable manned/unmanned platform. It is a concept that has utilised entirely new methods of design, testing,

and construction. As stated in Northrop Grumman’s media release, Vanguard’s development followed a new Digital Pathfinder approach, which revolves around a digital ecosystem and advanced production capabilities. These capabilities were used to analyse, build and test the wings of the Model 437 before the aircraft’s first flight.

The digital ecosystem reduces engineering rework and redesigns to less than 1% compared to 15-20%

using traditional methods. Through Digital Pathfinder, Northrop Grumman’s digital thread connected engineers, customers and stakeholders in a virtual environment, allowing them to foresee and solve the issues typically associated with aircraft programmes upfront and early – significantly improving programme performance and reducing costs.

Vanguard’s development relied on advanced manufacturing techniques, including producing a titanium structural



the USAF?



CLOCKWISE FROM IMAGE:

Scaled Composites describes the Model 437 Vanguard as "A conceptual design, based on the [unmanned] Model 401, exploring a multi-mission low-cost attritable aircraft"

Northrop Grumman

The Vanguard can carry up to 2,000lb of payload in multiple locations, including an internal weapons bay sized to accommodate two AIM-120 AMRAAMs

Scaled Composites

Test pilot Brian Maisler pictured in the cockpit of the Model 437, illustrating the relatively small size of the aircraft

Scaled Composites



bracket using plasma arc energy deposition. This innovative additive manufacturing technique forms a titanium part and is considered a first in the defence industry. At the same time, the Digital Pathfinder project applied advanced techniques to reduce the requirements for hard tooling while improving first-time quality and reducing manufacturing rework. This new approach to aircraft construction used by Northrop Grumman may give the company a significant advantage in the USAF and USN's competition to produce hundreds of highly capable autonomous drones.

When the illustrations of the Model 437 were first revealed in 2021, they were shown flying alongside and operating with manned aircraft, both fighters and other larger crewed platforms. The Model 437 was viewed as a strike platform and a protective escort to high-value airborne assets fitted with AAMs or equipped with side-looking imaging radar, speculated as two possible configurations.

The first flight of the Model 437 comes as the USAF finds itself in the precarious position of possibly being unable to afford its much-heralded NGAD fighter, or at least in the high-end configuration it first wanted when the concept was first unveiled as a DARPA study in 2014. According to recent comments by Gen David W Allvin, US Air Force Chief of Staff, at the recent Air & Space Forces Association held in London, the USAF may well be rethinking plans to build an expensive high-end fighter following the impact that both drones and other technology are making to the face of warfare. Allvin revealed that the service is shifting its dollars towards human-machine teaming and its pursuit of an operationally viable CCA: where these platforms fly alongside manned fighter jets and perform

several supporting missions.

The USAF has already confirmed that it plans to spend approximately US\$28bn in the next five years to develop NGAD and CCA programmes, which means a slight increase in NGAD funding, but this is still subject to how the USAF builds its FY26 Programme Objective Memorandum budget which is currently taking place.

The financial crisis the USAF is finding itself in has led some senior officials in the organisation to propose a new 'lightweight fighter concept' that would radically alter the way the service designs and procures fighters and, suggesting the service steps away from the high-cost, high-end capability platforms such as NGAD and choose smaller, lighter, cheaper aircraft that can be adapted to new challenges the service may face in the future, utilising a modular design. While this concept may, as yet not see the light of day, the potential of platforms such as Model 437 in both a manned and unmanned configuration flying alongside a revised and reduced NGAD USAF fleet may be the way ahead for the US to maintain its air dominance and have the necessary dollars to pay for it. **AI**



“Reluctantly, we have taken the decision to withdraw from the competition.” With those words, Airbus Helicopters confirmed what had been rumour inside the industry for several weeks, that it was ending its attempts to sell the H175M to the UK’s MOD to satisfy the New Medium Helicopter (NMH) programme. Airbus declined an offer to proceed to the Invitation To Negotiate (ITN) stage. The company stated that it had proven impossible to “responsibly” reconcile the MOD’s capability requirements and budget with a sustainable and profitable programme, going forward.

Lockheed Martin has also withdrawn, ‘no-bidding’ the S-70 Black Hawk. The American giant has concluded that its bid “could not meet its [MOD’s] minimum requirements in today’s market conditions”. It has been an open secret that the company had decided the ‘Percentage Win’ (PWin) was too low to continue investing in the campaign.

The issue for the Black Hawk is not its peerless operational credentials; more than 5,000 have been built, it is in service with over 30 countries and it has a combat provenance unmatched by any of its competitors (more than five million combat hours).

The Black Hawk’s problem for NMH was that it was not ‘British enough’; not enough of the budget could be spent in the UK to satisfy ‘social value’ demands, nor could it support a realistic export market of the ‘prosperity agenda’, given the multiple sources of UH-60 production.

It appears that Airbus has reached the same conclusion. The H175M is partially a ‘paper aircraft’ as the company has not built an H175M from scratch. In recent years, the sleek, black-painted demonstrator paraded around airshows and defence exhibitions may have ‘H175M’ on it, but it is an adapted H175. The production H175M would require lengthy (and expensive) certification to become a proper ‘military medium’, including extensive signature measurement and Defensive Aids Suite (DAS) effectiveness trials.

Airbus has also had to consider the start-up costs of a UK final assembly line. Coupled with a reduced programme scope, from a peak of 44 aircraft now scheduled to be 32 (likely lower), and doubtless multiple runs through the ‘Shipley Process’ to ascertain their Pwin, the company has also concluded that their chances of both winning the contract and delivering to a profit are too low.

Besides, Airbus already has two ‘wins’ from the fractured NMH programme.

The MOD has ordered six H145 helicopters, in a contract valued at £122m, to backfill the Puma supporting operations in Brunei and Cyprus. The uncertainty and delays in the NMH programme have also forced the MOD to issue Airbus a £300m+ contract to extend support to the Puma for an additional three years.

Which leaves NMH with the Leonardo AW149. Is it a straightforward choice for the MOD, then? Maybe not.

Despite Leonardo’s assurance that it can deliver a compliant bid on budget, several inside Defence remain sceptical. The nearest comparison for AW149’s



Airbus says 'Non'

Where does this leave the UK's NMH project?

Leonardo Helicopters is the sole remaining bidder for the UK's new medium helicopter (NMH) contest, with its AW149

Leonardo

cost is the £1.4bn paid by Poland for 32 locally manufactured machines in 2022. Even if we accept that the 2022 costs remain valid and that economies of scale are ignored, using the crude arithmetic of programme price divided by airframes, the Polish paid approximately £43m per airframe. Extrapolating that to the NMH budget would provide a maximum fleet size of 22-23. Conveniently, MOD has avoided noting what its minimal fleet buy would be. The defence ministry could find itself sucked into a programme that requires either additional funding or descopeing for AW to deliver to contract, with the 'conspiracy of optimism' in full effect as officers and civil servants hitch their 'career chariots' to it.

Secondly, a 'competition' with one bidder would be heavily scrutinised. Many in Defence already suspect that NMH was written around the AW149 to make up for an anticipated shortfall in work at Yeovil due to the completion of UK Wildcat orders and Merlin modifications. It is understood that MOD officials worked hard to keep Sikorsky and Airbus on

board for fear of appearing to preside over a coronation. However, the defence ministry's rules may halt the competition at this late stage and potentially recast the whole project. After all, the central tenet was one platform to replace Puma, Bell 212, Bell 412, and Dauphin N3, and has already been unpicked by the H145 purchase. Given the differences between the Pre-Qualification Questionnaire (PQQ) and ITN, the industry could rightly challenge sole sources as unfair.

A Strategic Defence Review (SDR) is also under way.

The political optics have changed. The new Labour government does not see Somerset as a traditional heartland. Helicopters are also not a strategic priority for any of the three services, and the £1bn of uncommitted NMH spend could be very attractive to protect key projects.

Cancelling NMH would be coherent. The Defence Rotary Wing Capability Study (DRWCS) advocated a four-type fleet: Apache, Chinook, Merlin and Wildcat. Puma was only extended to cover the transfer of the Merlin from the RAF to the

Navy. No 'small medium' was anticipated or funded beyond Puma's retirement in 2025. Cancelling NMH would not, therefore, leave a capability gap – despite there being an operational case for a smaller platform.

The further NMH slides to the right, the closer the next generation of helicopters becomes available. The prototype, Bell Future Long Range Assault Aircraft (FLRAA), is in build and, by 2028, a batch will be in operational test in advance of a fielding date of 2030/31. The NATO Next Generation Rotorcraft Capability (NGRC) and European Next Generation Medium Helicopter (ENGMH) studies will likely produce prototypes by the mid-2030s, aimed at starting to replace the likes of the NH-90 and Merlin by 2040.

Cancelling NMH now would buy time. It is time to rebuild the equipment budget and assess what programmes such as NGRC and FLRAA offer as replacements for the Merlin and Puma. Perhaps it will also offer the time to prevent the UK from rushing to buy a small, bespoke and expensive batch of 'yesterday's' helicopters, tomorrow'. **AI Paul Kennard**

On call for the



Marine Helicopter Squadron One (HMX-1) conducted several test flights with the VH-92A over the south lawn of the White House in September 2018
USMC/Sgt Hunter Helis

Sikorsky delivered the 23rd and final VH-92A Patriot to Marine Helicopter Squadron One (HMX-1), USMC, on August 19 at its production facility in Owego, New York, ending the programme.

This delivery means the helicopter fleet used to transport the US President and Vice President now comprises 23 VH-92As, divided between 21 operational examples and two test aircraft. The large fleet size will allow aircraft to be ready to support the executive airlift mission, undergo various maintenance and lifecycle upgrades and provide airframes for pilot and aircrew training.

Brigadier General David Walsh, the USMC's executive officer for air anti-submarine warfare, assault and special mission programmes, was present at the handover ceremony and commented:

"This exceptional team has successfully completed the programme of record for the VH-92A within budget and schedule. This helicopter not only embodies the hard work and dedication of those responsible for building and delivering the aircraft, but will remain a recognisable patriotic asset known around the globe for safety, security and reliability."

In May 2014, the Department of the Navy selected Sikorsky to develop the VH-92A (formerly VXX), a militarised derivative of the Sikorsky S-92A, to replace its ageing VH-3D and VH-60N helicopters, under the auspices of the USMC's Presidential Helicopters Program Office (PMA-274). The programme completed Milestone (MS) C on May 30, 2019, and received the acquisition decision memorandum (ADM) on June 8, 2019, authorising entry into production and deployment.

The programme was initially awarded

\$1.24bn for low rate initial production (LRIP) Lot I for six VH-92A aircraft, spares and support equipment in June 2019, with LRIP Lot II for six aircraft in February 2020 and the final LRIP Lot III for five aircraft in February 2021. Government testing to validate system performance and execute initial operational test and evaluation (IOT&E) was completed in April 2021. The USMC declared initial operational capability (IOC) for the VH-92A on December 28, 2021, followed by the White House Military Office (WHMO) commissioning programme.

Walsh noted: "This delivery represents a significant milestone and new chapter in the rich, 67-year history of Marines providing helicopter transport for the President of the United States."

Lieutenant General Bradford Gering, the USMC's deputy commandant for aviation, added: "The VH-92A Patriot brings increased capabilities for this no-fail mission



White House

supporting the Commander-in-Chief around the world.”

Sikorsky VP and general manager Richard Benton said: “Sikorsky’s highly skilled employees have shown their ability to innovate, manufacture and deliver these next-generation VH-92A presidential helicopters, which will be operating worldwide in support of presidential missions well into the future.”

On August 19, a VH-92A Patriot assigned to Marine Helicopter Squadron One (HMX-1) ‘Nighthawks’ flew US President Joe Biden from Chicago’s O’Hare International Airport to Solider Field to speak at the Democratic National Convention. This was the first time the US President had flown in the Patriot on an operational flight. On the day, the VH-92A became the first new platform designated to use the ‘Marine One’ callsign since the 1989 introduction of the VH-60N White Hawk executive transport and more than 60 years

since the VH-3D Sea King took over the role as the Presidential helicopter.

The culmination of this VH-92A flight ended what had been, at times, a problematic programme to secure a next-generation executive airlift mission for the US President. In 2005, Naval Air Systems Command awarded Lockheed Martin a contract for 28 VH-71 Kestrels, variants of the AgustaWestland AW101, for the mission, but the programme was cancelled in 2009 due to cost overruns. NAVAIR subsequently awarded Sikorsky the initial contract for six Presidential helicopters in 2014, with the first variant flying in 2017. According to Norman Polmar in *Proceedings* magazine, after the first flight “the helicopter subsequently failed to meet reliability, availability and maintenance thresholds, and although it was credited with achieving initial operational capability on December 28, 2021, it was not approved for presidential transport”

because of problems with the encrypted communication system and other issues.”

A 2020 Government Accountability Office report said that, in addition to reliability and communication system problems, the heat from VH-92A also damaged landing surfaces, including the White House south lawn: “In a September 2018 training event, the US Navy found that VH-92A’s exhaust damaged a [White House] landing zone. Programme officials stated that the training event did not represent a typical operational scenario since the lawn was exposed to the helicopter’s exhaust for longer than it would be under normal operating conditions.”

Despite criticism of the VH-92A, due in part to technical issues with the aircraft at the time, all of which were subsequently resolved, the VH-92A Patriot looks set to have a service life of more than two decades, mirroring that of the VH-3D and VH-60N. ■

Boom Supersonic's ambition to have a Mach 1.7 commercial airliner by 2029 is gaining momentum. Named Overture, the company may meet the call for a return to supersonic commercial flight by the decade's end.

Glenn Sands was at FIA2024 to hear the latest from this revolutionary start-up

The desire to reintroduce supersonic commercial flight back into the industry has been discussed since Concorde flew its final flight on October 24, 2003. In the years immediately following its retirement, many companies pitched ideas and showed countless illustrations of proposed supersonic designs, all seeking support from large OEMs. Environmental groups expressed concern that current aviation is already causing significant damage. Was there a practical need for commercial flights to operate above the speed of sound once more?

It is only now, through visionary companies such as Boom Supersonic, that commercial aviation is once again facing the possibility of practical supersonic travel daily. The Colorado-based start-up firmly believes that there is a need for this capability once again. Blake Scholt, founder and CEO of Boom Supersonic, discussed his company's progress at FIA2024 (Farnborough)

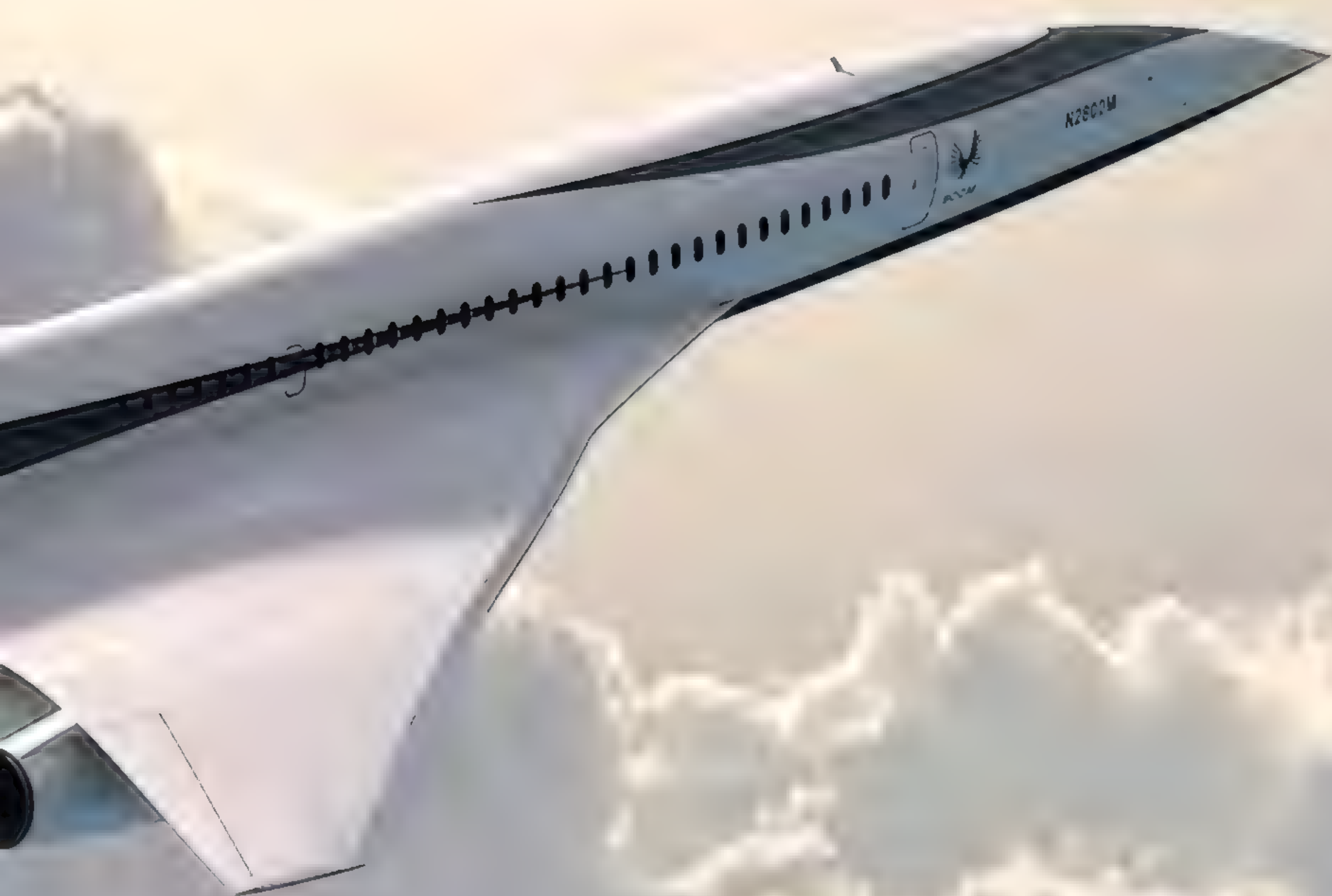
The demand for the return of supersonic passenger flights is strong, and Boom is positioned to shake up the airline industry with its 64-80 seat Overture

All images via Boom Supersonic



Supersonic

RENAISSANCE





at Mojave Air & Space Port California (see News, *Air International*, May 2024).

At FIA2024, Scholl provided an update on the flight testing of the demonstrator: "XB-1 is the aircraft that sets the foundation for our Overture airliner, and it demonstrates some of the key technologies for a renaissance and speed." Scholl explained in detail some of the systems involved in the XB-1's structure, comprising: "Digitally optimised aerodynamics, a carbon fibre composite airframe, advanced supersonic engine intakes and an augmented reality vision system for improved visibility when on the runway."

"XB-1 is the first independently developed supersonic jet and the first new civil supersonic aeroplane to fly since Concorde in 1969." XB-1 completed its maiden flight

International Airshow) in July amid a presentation that oozed the confidence and vision that resonates throughout the company.

"It's been two decades since either Boeing or Airbus launched an all-new airliner programme. We're in danger of going a generation without new airliners. We've stopped progressing and, in many ways, we've gone backwards," said Scholl.

Scholl was arguably correct in his opening address to the media present; while airliners have become more fuel efficient, fly further and are heading to that goal of running on SAF daily, the speeds have remained relatively unchanged. Scholl added: "It's never been clearer that passengers and airlines are not well-served by the duopoly [Airbus and Boeing] we currently have today."

It's a bold statement, but one Scholl is only too happy to back up in what he sees as his vision of meeting the needs of the airline industry and also shaking it up at the same time. At the core is Scholl's long-term belief that demand is there for the return of supersonic passenger flight, and Boom is ideally positioned to meet that demand by introducing a clean-sheet design for an aircraft – the company calls it Overture – that will carry 64-80 passengers and fly at Mach 1.7.

Scholl said: "Passengers and airlines are hungry for supersonic flight." He predicts that the demand for a supersonic aircraft like Overture could be as high as 1,000 aircraft, with nearly 97% of the passengers opting to fly it and 87% of consumers willing to change their preferred airliner. Scholl added: "All of us want to travel faster, can travel better, can experience what it's like not just in our city but on the planet, and to do that we need supersonic flight. We need to have faster aeroplanes develop faster, so today it's all about speed; it's about accelerating the supersonic renaissance."

From Boom's work towards supersonic flight, it's evident Scholl has a firm timeline in progress. The company has already flown its XB-1 supersonic demonstrator





“We were able to accomplish this ten times more capitally efficiently than any other supersonic programme in history”

Blake Scholl, founder and CEO, Boom Supersonic

on March 22 this year, returning safely to Mojave. Scholl said: “This was the first-ever landing of a human-piloted aeroplane using an augmented reality vision system for runway visibility.” It was an achievement that much of the wider aerospace media missed at the time. However, Scholl was quick to point out that XB-1’s maiden flight highlighted three ‘squawks’: “Two were relatively trivial issues and one notable item to address. We had better than forecast handling qualities on both pitch and yaw, but as our test pilot put it, ‘roll was a little bit exciting’. So, to reduce pilot workload, we added a digital stability augmentation system... which the team involved within the programme developed in just eight weeks.”

At the FIA briefing, Scholl added: “We have now finished installing the upgraded roll system on XB-1. As I speak the aircraft will be out on the runway today at Mojave for one final taxi test.” On August 26, the XB-1 flew for the second time from Mojave in the hands of Boom Chief Test Pilot Tristan “Geppetto” Brandenburg for approximately 15 minutes, reaching an altitude of 10,400ft and speeds of 232kts (227mph).

The impressive schedule means the XB-1

is on track to break the sound barrier later this year, becoming the first independently developed supersonic jet to fly faster than Mach 1. But the aircraft’s development and technology are to be the foundation for Overture, as Scholl explained: “XB-1 is important as a technology demonstrator and in terms of team and culture. I believe that small, focused, driven teams can do things that the legacy players can’t or won’t. We can do them faster and better. XB-1 was designed and built with just 50 people, including engineers, technicians and pilots.”

Scholl continued: “We were able to accomplish this ten times more capitally efficiently than any other supersonic programme in history. XB-1 has established the foundation of our safety culture.”

With XB-1 well on the way to achieving several notable firsts for Boom, the company’s cornerstone is the development of Overture, with EASA and FAA certification estimated by 2029, following which regular supersonic commercial flights will be cleared to begin. Scholl explained the programme schedule for the supersonic airliner: “We’re starting with Overture One, an all-business-class supersonic airliner for

trans-oceanic flying at fares 75% lower than it took to fly on Concorde. It means leaving Washington DC, and being in London in less than four hours.

“Imagine crossing the Pacific from Tokyo to Seattle in just four-and-a-half hours, or going from Sydney, Australia, to Los Angeles in eight-and-a-half hours.

“Flights like these will change how we travel, where we do business,” said Scholl.

With Overture primarily intended as a passenger aircraft, Scholl pointed out that Boom is already working with the US Air Force and Northrop Grumman in what he termed “the power of speed to situations where time matters most”.

A team of global suppliers, such as AIT, Collins Aerospace, Dimensional Energy, Honeywell, Leonardo Safran and StandardAero, is already involved in the development of Overture. The latter is set to play a significant role in the future with Boom.

However, it’s not only manufacturers that have shown considerable interest in Overture; according to Scholl carriers such as United, America Airlines and Japan Airlines are among those that have seen



CLOCKWISE FROM LEFT:

Scholl exclusively unveiled Overture’s flightdeck at FIA2024. Honeywell Anthem avionics suite and a new enhanced flight vision system have been included in the redesigned layout

Now that the XB-1 has completed its first two flights, the team will begin to systematically expand the flight envelope to confirm its performance and handling qualities through and beyond Mach 1

Overture has an all-business-class cabin configuration, with flights between Tokyo and Seattle in under five hours

XB-1’s landing gear was successfully retracted and extended for the first time, typical of second test flights. Additional objectives for this flight test were for the XB-1 team to assess aircraft handling qualities and activate a new digital stability augmentation system

Sound of a Symphony

As the first-ever purpose-built engine for sustainable supersonic flight, Boom's Symphony will power Overture. CEO Blake Scholl said: "Just 18 months ago, people asked why we would develop our own engines. The simple answer is that there are huge advantages in the ability to customise the engine precisely to Overture's needs. Also, it allows us to move much faster in development."

Despite causing controversy within the industry, it may well prove another positive move for Boom. The company has worked in partnership with engine manufacturer StandardAero to complete Symphony's concept design, build the first test parts and commenced hardware rig testing, with plans to run a full-scale Symphony engine core on a test rig by winter 2025. However, the company is already looking beyond Overture and has identified further commercial and military potential for the engine.

This has meant that Boom's existing partnership with StandardAero has evolved, with the company devoting 100,000sq ft of space for assembling Symphony engines at its facility in San Antonio, Texas: "With the ability to build 66 Overtures per year, we are going to need a lot of Symphony engines, which may well see other applications too. To build that many engines, it was best to select a partner with deep experience manufacturing both commercial as well as military supersonic engines. One of the benefits of working

alongside StandardAero as we develop Symphony is that we're designing the engine and manufacturing it together with a maintenance process, which will allow this engine to be easily maintained."

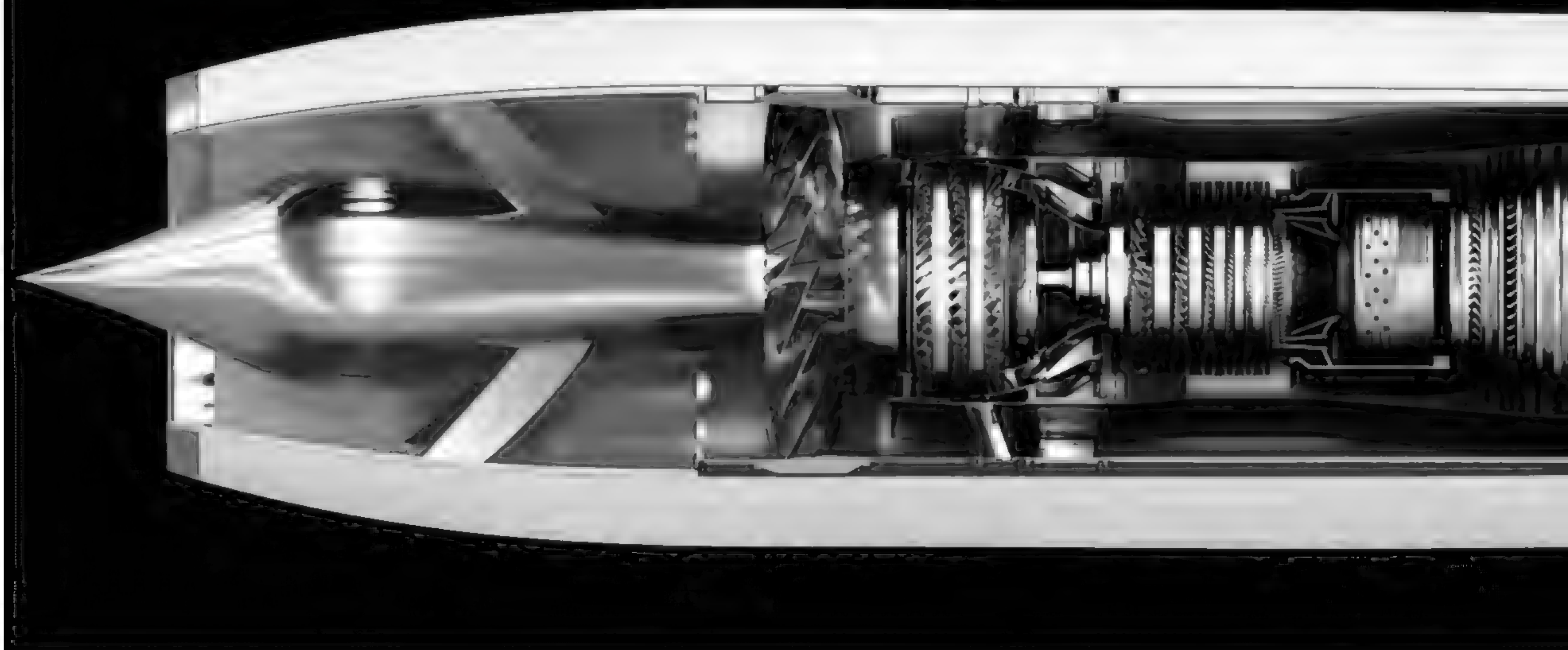
Scholl described how Symphony was designed digitally, testing and iterating the hardware in tandem: "Small focused engineering teams who build and test as they design are going to produce the best products fastest at the lowest cost. This is the intersection of digital engineering and digital manufacturing." An example of Boom's rapid development approach is that combustor rig testing occurred just a few weeks before FIA2024. This validation of much of the company's computational methods allowed the design to be refined for optimal performance.

Kratos, Colibrium Additive and ATI are also supporting Symphony's development, with ATI supplying custom superalloys for the engine that will offer reliable performance for extended periods at extreme temperatures.

Scholl believes that Overture is just the start of supersonic flight, with plans for second- and third-generation supersonic aircraft allowing flights overland: "In the future, we will need more supersonic jets than subsonic jets, just like we needed more Boeing 707s than DC-3s back in the day. The market for supersonic is bigger than the market for subsonic, and that will mean it will expand opportunities for all classes of passengers."

RIGHT: Boom has already identified commercial and military applications for its Symphony engine beyond Overture

BELOW: Scholl confirmed hardware testing is underway on the Symphony, with 3D-printed parts having already been produced, such as fuel nozzles and turbine centre frames





Boom has secured 130 Overture orders and pre-orders, with global airlines, including American Airlines, United and Japan Airlines, being among those signing up for the supersonic airliner

proceeding with Overture, Farnborough saw further announcements made by Scholl that focused on the design of the aircraft; two years ago, the initial production Overture design was revealed. He said: "Last year, we met the team of suppliers that are working with us to deliver Overture." Scholl also announced that the final configuration of the aircraft's Anthem flight deck has been completed and is five years ahead of anything currently flying.

The Overture flight deck has eliminated hundreds of small controls and is built around four 17in touch displays. This

aircraft, which will be 'gentle' to both pilots, passengers and the airframe.

"But pilots also sometimes want to land manually, and there are two different ways to achieve this. We're building on the augmented reality technology we used on XB-1 with two options for pilots. The first is the ability to see a camera view on the pilot's primary flight display by looking right through the nose of the aircraft and seeing the runway for landing as on XB-1.

"Additionally, we are incorporating a head-worn display so pilots can look through the lenses and see outside the



130 aircraft on order or pre-order. Scholl believes the impact of Overture will be huge in the way the industry currently operates.

He added: "Each year, tens of millions of passengers fly in first class or business class on routes where Overture can fly faster and fly profitably; by carrying these passengers, supersonic airlines are going to need well over 1,000 Overture aircraft. When we talk to passengers, most are looking forward to supersonic flight." Passengers admitted they would happily switch to an airline offering the supersonic option to save time. For airlines that have already placed orders for Overture, Scholl believes they will have a "competitive advantage for early adopter airlines" in the future, compared with traditional fleets.

In June this year, Boom opened its Overture Superfactory, which Scholl described as "a major milestone toward ensuring the United States continued leadership in aerospace manufacturing". From ground-breaking to completion, the production line at Greensborough, North Carolina, took just 17 months.

Scholl continued: "It's a 175,000sq ft facility on a 62-acre campus, with the first final assembly line designed to produce 33 aircraft per year, with space reserved on site to build at least two, possibly three assembly lines in Greensborough, producing up to 100 Overture aircraft every year."

Given the speed at which Boom is

means every single function of Overture is available through touch. An example explained by Scholl is that if there was a need to "pull a circuit breaker in an emergency, you don't have to go hunting for it; the task can be accomplished on the screen". Further additions to the flight deck are trackpad cursor controls, which mean during turbulence, every essential function will still be easily available for the pilots. Scholl continued: "On today's flight decks, pilots have to choose between automation and having a tactile feel of how the aircraft is flying; this should not have to be a choice, so we have incorporated dual force feedback sidesticks, which means you can actually feel how the aeroplane is flying and you can also feel how your co-pilot is flying.

"Overture's fly-by-wire system sends an artificial feel to the stick, giving the pilots a tactile stick and rudder experience on top of the most advanced flight control system. The sticks move in tandem for exceptional situation awareness."

Having highlighted the performance of Overture, Scholl was keen to highlight how far Overture's technology has come in terms of the last regularly flown supersonic commercial aircraft, Concorde, where the aircraft's unique configuration in the landing pattern is remembered by all who were fortunate enough to see it. Scholl explained: "We expect most of Overture's landing to be automatic, as we have built the most advanced 'autoland' system into the

aeroplane and experience a similar effect to that seen on the F-35."

A final point Scholl was keen to make regarding Overture's flight deck was its ability to be upgraded. Could this be a path other larger OEMs follow in the future? "Today's flight decks are filled with many switches, buttons and controls fixed in the hardware. They can't change after the aircraft has been shipped to the client. Because Overture is designed around software and touch screens, we can deliver over-the-air upgrades, meaning new features and improvements can be delivered regularly. However, airlines will have full control over how software updates roll out across their fleets," explained Scholl.

With some of the best-known OEMs within the aviation sector partnering with Boom on the Overture project, it was fitting that Jim Courier, CEO of Honeywell Aerospace Technologies – a company that's involved in every sector of aerospace development, and provided the touchscreens for the Anthem flightdeck's touchscreens – should offer his thoughts on what Overture looks set to bring to the world. He said: "The Boom team have been a transformation force within this industry since beginning their journey nearly a decade ago.

"It's been inspiring to see how their vision has become a reality and together, we share a vision of making supersonic commercial flight a reality again." **AI**

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Five years flying over **fire & ice**

Director General of the ICG, Georg Kristinn Lárusson spoke to **Sven van Roij** about five years of flying the Airbus H225 in a challenging and dynamic environment with constantly changing weather and complex missions



Reykjavik's domestic airport houses the fleet of the Icelandic Coast Guard (ICG), locally called Landhelgisgæsla Íslands. It comprises three Airbus H225s, and one fixed-wing Dash 8 Q300 maritime surveillance aircraft.

The ICG's operating area ranges from countless waterfalls to dangerously cold seawater and glaciers to newly formed land rising from the earth's core. Georg Kristinn Lárusson, director general of the ICG for nearly two decades



The Icelandic Coast Guard (ICG) has three Airbus Super Puma H225s at its disposal

All images by Sven van Rooij



BOTTOM:

During a recent training exercise, and H225 crew was requested to locate a missing fishing vessel. The ICG, equipped with the MX-15 imaging system, ensured the ship was quickly found

BELOW:

H225 pilot Jens Sigurdarson continued to fly throughout the recent eruptions in Iceland to ensure the ICG continued to provide emergency cover when requested

“The H225 is also a true all-weather SAR helicopter. Our crews can continue their mission in virtually all types of weather, including severe icing conditions”

Georg Kristinn Lárusson,
director general, ICG



described a busy year: “Last year, the ICG completed a record number of 314 helicopter missions, with the busiest period being when tourists visit in June, July, and August. Most of these missions are for medical evacuation (medevac) and search and rescue (SAR) operations on land, while 30% are conducted at sea. We are fully equipped and prepared to handle the high demand during the summer months.”

New kid in town

Six helicopters were written off or damaged due to accidents in the early days of helicopter operations with the ICG. Over the years, accident rates decreased due to fleet modernization. “Our first helicopters, such as the Bell 47J and Sikorsky S-62, were older in design and lacked power. With the introduction of more capable helicopters, the safety and capability increased,” Lárusson stated. “The Eurocopter SA365N Dauphin was our first multi-engine helicopter suitable for Visual Flight Rules and Instrument Flight Rules. The Aérospatiale AS332L1 Super Puma was also equipped with a four-axis autopilot, a fully capable de-anti-icing system and a dual hoist. Later, the Super Puma became the type we first flew with night vision goggles,” he continued.

Flight safety, capability and safety took an even bigger leap with the arrival of the first Airbus H225 in April 2019. The helicopters, which feature Automatic Flight Control Systems (AFCS), replaced the three AS332L1 Super Pumas. The H225s are leased via Norwegian helicopter lessor Knut Axel Ugland Holding AS. The fleet has a TrakkaBeam A800 searchlight, a WESCAM MX-15 Multi-Sensor, a Multi-Spectral Imaging System, and a double hoist. The third and final H225 was delivered to the ICG on May 4, 2021. The ICG named the three aircraft after the Norse gods Gná, Gróa and Eir.

Unaffected by the vexing weather

Iceland is located between the North Atlantic and Arctic Oceans and is known for its unparalleled natural beauty. The island is home to under 400,000 residents, which increases fivefold yearly due to these visiting tourists. Lárusson said: "We can conduct SAR and medevac missions within the Icelandic exclusive economic zone (EEZ). The Icelandic Search and Rescue region covers 1.9m km², while the EEZ is approximately 700,000km².

"Our helicopters are specifically outfitted for rescue operations and feature external fuel tanks as standard to increase range. Additionally, we provide support to police or civil protection services and can deploy helicopters equipped with Bambi buckets in the event of wildfires."

The island is vast and has deep gorges and high mountains. The environmental factors, combined with Iceland's subpolar oceanic climate, regularly create multiple types of weather within a day. Winter conditions can make maintenance in the cold difficult, and lubricating oils take on a thicker composition. According to the Director General, this is rarely a limiting factor: "Our helicopters are designed for this specific weather and operational conditions. The manufacturer specifies which lubricants should be used when operating in cold weather.

Cold temperatures can be tough on the engines, but this can be minimised by storing the aircraft in warm hangars and accessing ground power units. In addition, crews on duty monitor the weather on duty and before their mission.

"The H225 is also a true all-weather SAR helicopter. Our crews can continue their mission in virtually all types of weather, including severe icing conditions because the type is fully de-icing certified. Restrictions during deployment are the start-up limit of 55kts or freezing drizzle or rain."

A hostile landscape

Besides operating in diverse weather conditions, the ICG has been regularly deployed during volcanic eruptions in recent months. "Our crews have been deployed to monitor the area along with scientists from the Icelandic Meteorological Office (IMO) and the civil protection service before and after the eruption. The crews have conducted hoist missions with electrical cables over the new lava and are prepared to evacuate in the event of an eruption," Lárusson explained. With these flights, crews provide a record of information to the government. With details about



ABOVE:

Icelandic Coast Guard insignia

BELOW:

The ICG schedules one H225 for maintenance at a time within its well-equipped hangar





crevasse size, thermal image and lava flow direction, an effective action plan can be implemented on the ground.

The H225 fleet is equipped with two powerful Turbomeca Makila 2A1 turboshaft engines. According to Lárusson, no engine, intake, or exhaust modifications have been made to operate near lava flows, volcanic eruptions, or ash clouds. The flights are conducted safely without impacting the engine or other components. ICG pilot and captain Jens Sigurdarson added: "Flying had not

been a problem for us during the recent eruptions, where we have had flowing lava streams in particular. Relatively few ash particles are released from that. During the explosive volcanic eruptions under the glacier Eyjafjallajökull in 2010, huge amounts of ash were released. That shut down air traffic for over a week. At first, we were not allowed to fly then either. Shortly after that, zones were designated where we were or were not allowed to fly, depending on the ash cloud's shape and direction of movement."





Small fleet availability

Combining diverse tasks, a small fleet, an annual influx of visitors, and requiring a forward base brings challenges. It takes over an hour to fly to the island's northern side from the base at Reykjavík Domestic Airport. The ICG has found a practical solution to this. Sigurdarson explained: "If we head out for an injured person further away, the Dash 8 Q300 flies to an airfield closest to the injured person. We provide the rescue, fly to the airfield, and the fixed-wing will then fly the casualty to the hospital in Reykjavik as soon as possible. This solution ensures that the victim receives medical help faster; after refuelling at the airport, we are also ready for a new assignment."

Lárusson attributed the failure to disperse crews and aircraft across different locations on the island to reduce intervention time to a restricted budget. "Multiple forward stations are expensive for a country with only 380,000 people but responsible for such a large area. With the current setup, we have the whole operation in the same place, and most of the population lives in and around the capital area," he explained.

The '225s main gearbox has a low-time precautionary maintenance schedule. Lárusson elaborated: "The main gearbox maintenance schedule is not a limiting factor, but rather a lack of available



CLOCKWISE FROM ABOVE:

ICG's Super Puma H225s fly with a crew of two pilots, a rescue man, a hoist operator and a doctor

A weekly flight schedule allows for training associated with a drowning incident. Here, an H225 crew practice with the Coast Guard vessel Freyja

The Icelandic Coast Guard's helicopter fleet was completely renewed between 2019 and 2021 and has never been better equipped. Three Airbus H225s outmatch previous models, having better carrying capacity, improved de-icing equipment and an improved autopilot system

Iceland has stunning deep gorges and high mountains. The environment, combined with the country's subpolar oceanic climate, regularly creates multiple types of weather within a day

missions last year and in the first half of this year, 96 rescue missions were flown.

On the job

The ICG crews work one-week shifts, which amount to 168 hours. Lárusson said: "They are on standby from home and must live within a 15km radius from the airport. It's a seven day on, seven day off system. A flight plan is created each week to outline all scheduled flights, including training, law enforcement, or other missions. Crews must be prepared to respond to scrambles as they occur, which may require the cancellation or rescheduling of previously scheduled flights. Technicians work daytime and overtime when needed. We always aim to have all of them licensed and certified for line and base maintenance on our helicopter fleet."

REYKJAVÍK
Reykjavík Airport is the main domestic airport and houses the ICG fleet since most population lives in and around the capital. The characteristically shaped Hallgrímskirkja Church in the city centre is visible in the background.

nation's support for Allied and NATO forces in Iceland. Therefore, the ICG is also responsible for the Keflavik Air Base.

Although there are options to arm the H225 with Airbus' platform-interchangeable and onboard weapon system 'HForce', the ICG's helicopters remain unarmed. To help keep Icelandic airspace secure, NATO frequently conducts Icelandic Air Policing missions from Keflavik. Allies deploy to the air base three times a year, with one rotation lasting three to four weeks. The ICG is responsible for providing SAR capabilities with its helicopters when air policing is conducted in Iceland.

Future proof

Established in 1926, the ICG has evolved significantly over the past



technical manpower, lack of onsite spare parts, and longer delivery times of spare parts. Other operators in our area have stated they need a fleet of five or six helicopters to constantly have two available.

"The ICG scheduled maintenance program schedules one H225 for maintenance at a time, keeping two operational. For safety reasons, a second H225 must be a backup if a helicopter deployment exceeds 20 nautical miles. In doing so, we achieve an availability rate where 98-99% of the year, we have one H225 available and 60% of the year, we have two H225s at our disposal. With six crews – each consisting of a commander, co-pilot, rescue man with EMT-A, hoist operator with EMT-B, and sometimes a flight physician from the state hospital – our goal is to have two crews and two helicopters readily available 24/7."

In this regime, the ICG flew 314 rescue

Despite labour market shortages, all positions within the Icelandic unit have been filled. The ICG's annual budget allows for six helicopter crews, which gives around 75% availability of two crews year-round. The Director General indicates he needs seven crews to increase crew availability to 95+%. The ICG has a very low turnover of personnel. Lárusson considers this extraordinary: "This is likely the most desirable job for helicopter pilots here in Iceland. However, each helicopter pilot accumulates around 200 flight hours annually, which is very low. It takes co-pilots many years to advance to commander."

Iceland has been a member of the North Atlantic Treaty Organisation (NATO) since its foundation in 1949. The ICG is responsible for the day-to-day execution of security and defence-related tasks in Iceland and for implementing the host

98 years. Lárusson explained: "Our responsibilities now encompass a wide range of tasks, including combating illegal activities such as illegal migration and drug trafficking, enforcing fisheries regulations, monitoring and responding to pollution incidents, protecting natural resources and the environment, as well as conducting salvage and rescue operations.

"The ICG is now well-prepared to respond swiftly to crisis situations, including rescuing distressed individuals at sea or on land, providing urgent medical transport, and assisting vessels within the country's jurisdiction. The future of the ICG is bright. We have never been as well-equipped, and our crews and personnel are world-class. It has been an honour to witness the flourishing of the coast guard over the last two decades." **AI**



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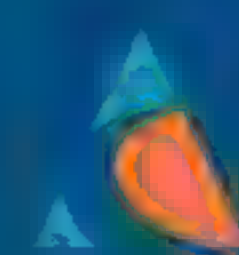


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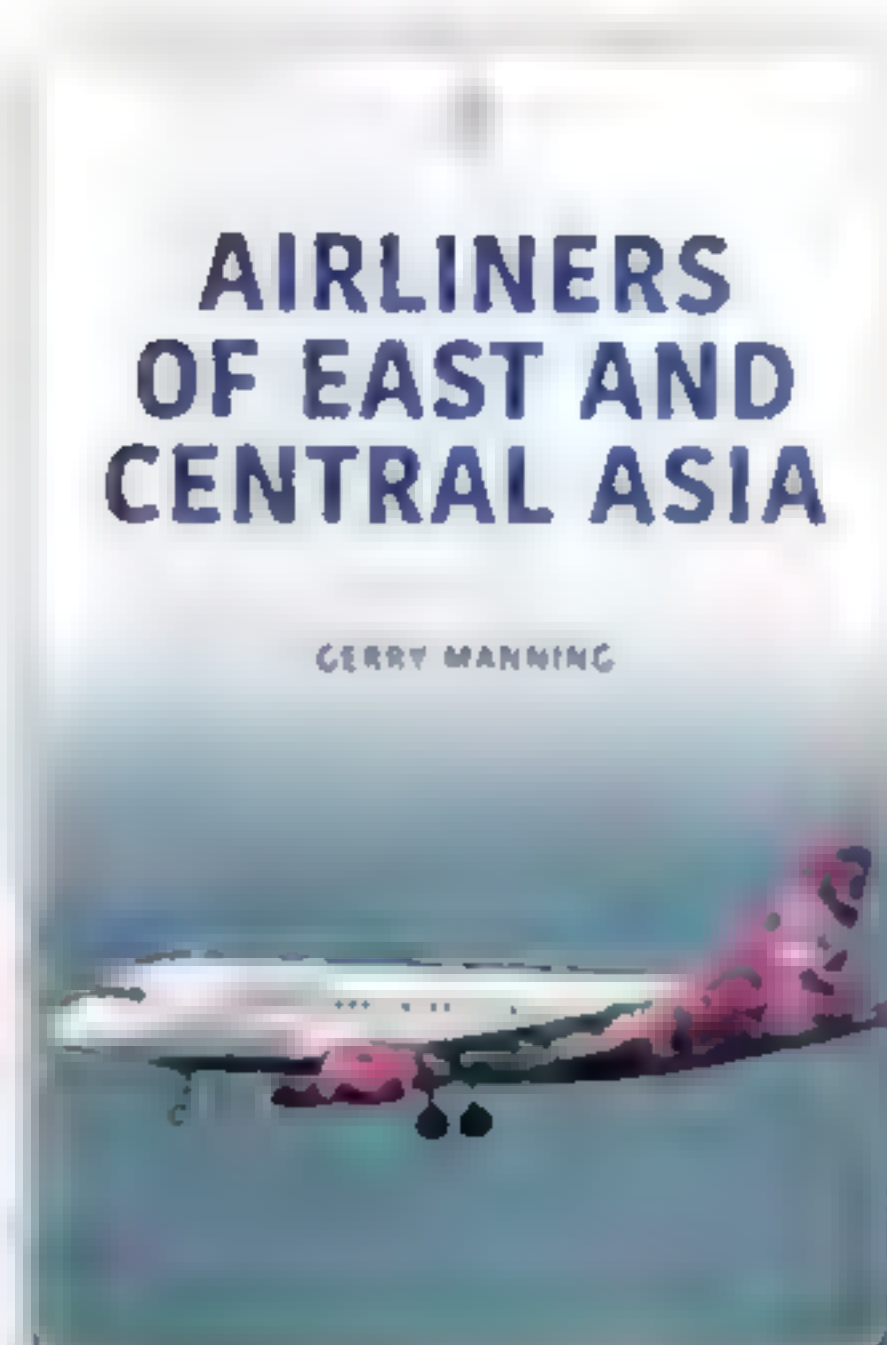
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Leonardo's AW159 is the latest-generation multi-mission, high-end war-fighting helicopter, delivering unparalleled tactical capability in a compact and robust airframe. As an evolution of the highly successful Lynx helicopter, the AW159 provides new technologies and capabilities, building on customer operational experience gained across land and maritime domains, offering a fifth-generation helicopter that may well be on the verge of securing additional overseas sales
All images via Leonardo, unless stated

On the prowl



Once unofficially referred to as the Lynx Mk.10, Leonardo's AW159 Wildcat is much more than an upgrade; what emerged is a completely new platform within the light-lift maritime sector, as Adam Clarke, managing director of Leonardo Helicopters UK, tells **Glenn Sands**

There's been a substantial increase in global maritime and littoral operations by navies worldwide in recent years as the West's operations pivoted from a decade-long conflict in Afghanistan and Iraq. Helicopter missions have, in part, returned to the multi- 



faceted style roles witnessed during the Cold War of the 1980s, particularly those within the maritime environment.

This change came at a time when many West and NATO allies, which had been committed to continuous operations within a 'hot and high' environment, also felt it was time to upgrade or renew their helicopter fleets. These fleets had endured flight hour increases far in excess of what had been predicted during normal peacetime operations. There was a swath of new types entering service, not all of which proved successful, with some nations needing to rapidly rethink and, in some cases, re-buy other types after just

a few years.

For the UK, Leonardo has long been the chosen OEM in supplying helicopters to its armed forces, and the current focus within the sector is the debate relating to the new medium helicopter (NMH). Following both Airbus and Sikorsky withdrawals recently from that competition, Leonardo is the sole contender, and the outcome of the NMH is left to what emerges from Labour's defence review, and its commitment to increase spending to 2.5% GDP, if the country can afford it, after a review of defence strategy.

With much of the wider aviation media's focus on Leonardo's push towards the

NMH competition with the AW149, Adam Clarke, managing director of Leonardo Helicopters UK, was keen to promote the other star within its portfolio, the AW159 Wildcat, at the Farnborough International Airshow in July; he revealed that new customers for the Wildcat may well be on the horizon. The company is currently in discussions with several potential customers. Clarke spoke to *Air International* on the current status of the Wildcat, what lies ahead for the AW159 and what the platform is bringing to the UK's armed forces.

He said: "The AW159 represents the most recent capability offered by Leonardo





in the maritime market segment. With a fully integrated avionics and mission suite, coupled with a tactical processor and military customer Human Machine Interface (HMI) delivering advanced situational awareness to the crew, the AW159, or Wildcat as it is known to the British armed forces, is an operationally capable and cost-effective multi-mission platform.

“Our expertise in ship-air interface is recognised through customer requirements for a platform to conduct demanding maritime missions. A modular ‘mission kit’ of configurable equipment for the AW159 enhances its true multi-mission

capability, ensuring the platform can be progressively updated,” Clarke continued.

“AW159 capabilities are continuing to improve and evolve as technology becomes available and customers develop operations requirements such as Crewed Uncrewed Teaming (CUC-T) and Airborne Launched Effects (ALE) as examples. As many operators look to modernise and upgrade their current fleets, we are working closely in a partnership that continues to support and improve in-service fleets with an understanding of individual customer operational requirements and budgets to deliver cost-effective solutions to meet mission

requirements and demands.”

The maritime light helicopter market is one of the most buoyant at the moment, with navies seeking that extra ‘combat mass’ element, which can operate safely from single-spot combatant flight decks and other aviation-capable ships, so removing the reliance on large, expensive carriers. Leonardo and Airbus are seeing the global ‘pull’ in the market, with Sikorsky and the Seahawk being the only other significant OEM. Clarke was quick to point out the benefits of the AW159 within the light-lift maritime helicopter sector: “It’s designed to operate safely from single-spot flight decks in adverse

ABOVE: Since the first successful firings of the Thales ‘Martlet’ Lightweight Multirole Missile (LMM) from the Wildcat in 2020, the Royal Navy has continued to develop its tactics, techniques, and procedures with successful missile firings against aerial targets. The helicopter has proven its ability to engage land, sea, and air targets

LEFT: Royal Navy pilots have praised the ease with which the Wildcat can be flown in challenging weather conditions around the ship, which is due to the Digital Automatic Flight Control System (DAFCS) and next-generation avionics on the Wildcat



“...the AW159 has several potential nations who are showing an interest in the platform”

Adam Clarke,
managing director,
Leonardo Helicopters UK



environmental conditions of poor weather and high sea states. The AW159 is one of the key protection assets for today's and tomorrow's Royal Navy fleet, delivering a multi-mission capability for surface and sub-surface operations."

Since the Wildcat entered operational service with the Royal Navy in 2015, crews have praised the helicopter's cockpit configuration and ease of use. Much was learnt from the years of operating the Lynx, which had long been in service and underwent numerous upgrades during its career with the Fleet Air Arm. Despite this, pilots and observers still often found themselves reliant on maps and associated 'paperwork' in the cockpit. Clarke said none of this is the case within the AW159's cockpit: "Being a network-

enabled helicopter, the AW159 includes the latest communications and navigation systems and sensors, which can be used with a wide range of air-to-surface and sub-surface weapons.

"The tactical processor and HMI were designed from the outset to allow the aircrew tactical advantage within the modern battlespace, and we're continuing to invest in the platform to ensure the Wildcat's capabilities continue to increase."

The reputation of the AW159's Tactical Processor and HMI, which has been developed in conjunction with the UK military, allows the Wildcat the fastest Observation, Orientation, Decision, Action (OODA) loop for any helicopter available in its class, Clarke said: "Tactical HMI was designed and developed with input from

the UK military to deliver a highly effective and efficient architecture to enable rapid development of the tactical picture. We aimed to provide an intuitive system with minimal button presses to generate action and plot.

"The adoption of a collaborative software development and feedback approach contributed to the rapid development of the HMI architecture. This approach resulted in mission sensor and HMI integration that is able to deliver a high-capacity and efficient structure providing world-leading collection, filtering and dissemination of tactical information," Clarke continued.

"The versatility of the integrated mission sensors through the Tactical Processor enables the crew to manage the tactical



One of the AW159 Wildcat's roles is fleet protection within a Carrier Strike Group. The missile is a prerequisite for performing this role. In addition to dealing with multiple surface threats, the LMM Martlet allows operators to engage air targets, such as UAVs and other crewed systems, giving the Wildcat greater teeth and the adversary more to consider when the Wildcat is airborne

LPhoto Chris Sellars/UK MOD Crown Copyright

information displayed, thereby maximising tactical situational awareness and increasing crew efficiency.”

Recent events have shown an effective rise in the use of unmanned aerial vehicles (UAV) within the battlespace, adding another offensive layer to combat or work alongside. As nations seek to allow both their fixed and rotary-winged assets to operate in partnership with such platforms, Leonardo has been keen to integrate the AW159 into this emerging tactical scenario.

Clarke explained: “In September 2020, we successfully demonstrated the AW159's unique crewed-uncrewed teaming integrated capabilities between a crewed and an unmanned aerial vehicle. This occurred in the UK during trials between an AW159 and a semi-

autonomous UAV from Callen-Lenz Associates. This was a UK first for seamless integration of a UAV into a helicopter mission system – allowing the Wildcat crew to control a UAV platform and sensor system from the cockpit as if it was one of the helicopter's on-board sensors,” Clarke continued.

“By integrating control of the UAV into the Wildcat mission system, Leonardo was able to minimise crew workload, allowing them to maintain focus on a mission while simultaneously controlling the UAV – this is the first time such an integrated capability had been demonstrated in the UK on a military aircraft. A ‘Gateway Processor’ supplied by Callen-Lenz Associates was used to interface with the semi-autonomous UAV.”

The solution Leonardo provides allows the Wildcat crew to control both the flight path and payload of the UAV, a capability known as level of interoperability (LOI) 4, using an efficient and effective task based on HMI rather than the more operator-intensive approaches employed on some other systems.

Clarke added: “Combining the strengths of crewed and uncrewed platforms, CUC-T has the potential to play a transformative role by increasing the situational awareness, tempo, lethality, survivability and combat mass of aviation forces, significantly reducing crew workload and crew to focus on the mission at hand.”

This ‘new’ teaming enhances air support mass capability in both the land and maritime environments while allowing ➤

CLOCKWISE FROM RIGHT:

The Wildcat's infra-red engine suppression and faceted tail design reduce its thermal and radar signatures. Extensive redundancy in structures, avionics, and critical systems, combined with a proven 30-minute run-dry transmission capability, ensures the highest standards of safety

POPhot Jay Allen/UK MOD Crown Copyright

The Wildcat has been proven to interface seamlessly with uncrewed systems without adding hardware or crew. This provides a combination of systems with greater loiter persistence and flexibility to perform complex maritime operations

LPhot Matt Bradley/UK MOD Crown Copyright

The flexible avionic architecture and comprehensive suite of available equipment enable the delivery of configurations and capabilities to meet customer mission requirements whilst providing growth capability in both avionics and mission systems, allowing customers to adapt the AW159 to meet their specific operational needs strategically. It's a sales approach that Leonardo is keen to stress to potential customers

for extended and complex operations to be conducted with a mix of platforms and systems in the foreseeable future. Clarke added further detail to these trials: "As a live example for a prospective programme, in relation to the New Zealand maritime helicopter replacement programme (MHRP), for which Leonardo is proposing the AW159, with the uncrewed element, we will offer the AWHero, which achieved military certification and demonstrated its capabilities in multi-national naval exercises. Acquiring both crewed and uncrewed systems from the same source can reduce integration complexity and logistical requirements."

The three candidates for the MHRP competition are the Airbus Helicopters NH90, Sikorsky MH-60R Seahawk and the AW159. The winner is speculated to be in operational service by mid-2027.

The gradual addition of increasing the weapons portfolio and integration to the Wildcat with the Royal Navy has been a carefully, if not at times prolonged process, with some critics keen to see the platform have an anti-ship capability sooner. Clarke explained that the process was well in hand but the company and the MOD had kept it away from the attention of the specialised media. Some details of the weapon's trials are still deemed sensitive, but Clarke provided an overview of the early period, particularly establishing an anti-surface capability for the AW159.

"For the AW159, the Future Anti-Surface Guided Weapon (FASGW) programme was awarded by the UK's MOD in 2014 in order to fill the anti-surface warfare (ASuW) gap on the Wildcat that existed due to the lightweight short-range air-to-surface Sea Skua then due to go out of service.

"For Leonardo, the contract covered the integration onto the Wildcat of a light weapon, the Martlet, manufactured by Thales UK, and a heavy weapon, Sea Venom, manufactured by MBDA."

Integrating both missiles onto the Wildcat's relatively small airframe required



adding what Clarke refers to as the Leonardo Weapon Wing. He said: "The wing was designed and manufactured at Leonardo's Yeovil facility and first trialled in 2019. The range and endurance requirements that the MOD placed on us meant the design had to be a new aerodynamic style wing in order to carry anti-surface weapons. The new weapons wings were found to provide a significant improvement in lift while at the same time allowed the performance requirements to be met, despite the increase in weight of the AW159 when carrying the additional stores.

"When designing the wing, Leonardo's team had to consider the capacity to carry stores versus the wing's weight and the design complexity versus performance benefits.

"The design team had to begin with what the optimised firing position would be for the weapons' free space and design the wing to achieve this. Additional considerations had to be given to the crew entry and exit from the aircraft, as well as other Royal Navy requirements in terms of deck operations, handling and loading, which resulted in the cantilever design."





Leonardo and Thales UK announced in May 2020 that the first successful firing of the Martlet lightweight multi-role missile (LMM) from an AW159 had occurred. The trials were conducted as part of the MOD's FAGSW programme. The successful firings demonstrated that the Martlet and AW159 platforms had been integrated.

Further trials were to continue with this combination, with the Royal Navy announcing in October 2021 that it had conducted the launch of a Martlet LMM at an inflatable target in the sea for the first time during frontline operations. The navy confirmed in a statement that "in 0.3 seconds, the missile detached from the Wildcat HMA Mk2 helicopter, accelerating to 1.5 times the speed of sound towards its target".

Clarke pointed out to *Air International*: "The Wildcat Martlet missile tests demonstrated what can be achieved together with industry partners. The recent successes highlight thorough collaboration on the platform and its on-board technologies; together, we are propelling the FAGSW programme to new heights of success and innovation to deliver enhancements required by the services."

When asked about timings for further trials relating to FAGSW, Clarke could not reveal any specific details but continued to discuss other trials.

"Leonardo has completed a number of live trials in the UK that will underpin the development of an ALE [air-launched effects] capability. This capability involves releasing and controlling a drone in mid-air from the host aircraft, such as helicopters.

"These exercises have boosted company knowledge in the CUC-T and ALE data management, laying the groundwork for future more complex trials. The field of ALE is one of the newest applications of drone technology and has the potential to dramatically increase the survivability of military aircraft and increase force effectiveness. By launching teams of sensor-equipped drones or other payloads that can then fly miles ahead of a Wildcat, for example, crews can operate at stand-off ranges and deliver effects with extreme precision.

"The trial built upon a Leonardo demonstration in September 2020, integrating an uncrewed aircraft into an AW159 mission system, allowing the crew to control the drone from the cockpit using

their on-board sensors. In the December trials and collaborating on CUC-T control software with Anduril Industries, Leonardo employed several ALTIUS-600 drones produced by Anduril drone-specialist subsidiary AREA-I," said Clarke.

ALTIUS drones are designed to be launched using various methods, including common launch tubes. They are capable of installation on military helicopters such as the AW159, as well as ground vehicles, surface vessels and high-altitude aircraft.

Clarke continued: "During the trials, teams from Leonardo and Anduril Industries were able to evaluate and gather real-world performance data on a range of hardware and software components critical to future collaborative drone capabilities. The team developed and practised the drone-to-aircraft co-ordination, flight manoeuvres, waypoints, loiter positions and overall command and control necessary for multiple aircraft to function together autonomously. The exercises have boosted the company knowledge in CUC-T and ALE data management, laying the groundwork for future more complex trials." This may well involve additional

participation from Wildcats in the future.

No matter how advanced, capable and complex the Wildcat looks set to become in the following years, once in service, it is ultimately down to the ship's maintainers to ensure that the platform is always available for the next sortie. Clarke did not forget this point, saying the fundamental maintenance requirements and ease with which they can be accomplished have been a core factor throughout the progress of the AW159: "The AW159 maintenance policy builds upon 40 years of Lynx operational experience gained from operators' experience and logistics analysis, with over two million flying hours to date. It enabled us to develop an on-condition maintenance policy with scheduled procedures kept to a minimum to deliver efficient operating costs and increased platform availability.

"The maintenance schedule is derived through the application of Reliability Centred Maintenance methodologies that generate individual tasks and their frequencies. These tasks can be carried out as individual inspections on the AW159 or grouped by aircraft systems' task frequency or aircraft zones. This approach provides operators with the flexibility to plan maintenance around operational and environmental situations, thus enabling the optimisation of available maintenance resources, maximising aircraft, in this case, Wildcat availability," Clarke continued.

"Designed from concept for military maintenance in the field, with attributes and support facilitating maintenance with minimum personnel and support equipment. The fully marinised design, utilising wet assembly techniques for structural joints, inhibits the ingress of water, and the manufacturing techniques inhibit potential water corrosion points.

Embodiment of environmental coatings on exposed systems such as the Wildcat's undercarriage and rotor head deliver corrosion protection, reduce downtime and enhance operational availability."

Asked what the future looks like for the AW159 in terms of its emerging capabilities, particularly within the maritime environment – which is proving to be an ever more volatile global setting at present – Clarke replied: "Investment and development continue with the AW159 by Leonardo, and it will expand with the FASGW anti-surface weapon capability programme. We see a great future for the AW159 as a versatile naval and land helicopter designed for operations in harsh maritime environments such as the southern oceans. It can support single-spot combatant operations and offers force interoperability with coalition allies and five-eyes partners.

"The AW159 has low operating costs and requires fewer crew and maintainers than rival platforms for embarked operations."

At the recent Farnborough International Air Show, Clarke stated during a Leonardo media briefing details of its current active campaign with the aircraft: "Leonardo sees tangible green shoots with the international outlook of the AW159, spanning Asia, the Middle East and in particular New Zealand.

"While we await full details from the New Zealand Ministry of Defence in the form of a request for tender, we can say that Leonardo will put forward the AW159 Wildcat helicopter for the crewed element of the MHRP. The AW159 is a proven and cost-effective multi-mission platform with the UK government as a reference customer. It meets New Zealand-specific requirements and has full support from the UK government." **AI**

An asset which packs a significant punch for operational commanders, the AW159 Wildcat significantly enhances the Royal Navy's ISTAR, SAR, maritime interdiction, anti-surface warfare, anti-submarine warfare and logistics support operations, all the time, remaining fully integrated and interoperable with other naval, NATO and coalition assets

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Drones

door-t



The commercial drone market continues to evolve with applications from cargo deliveries to supporting search and rescue missions.
Mark Broadbent reports

ABOVE:
Small multi-copters undertaking cargo delivery are an increasingly common sight
Skyports Drone Services

OPPOSITE:
In July 2024, the US FAA authorised Zipline to deliver packages by drone while using unmanned aircraft system traffic management
Zipline

Remotely-piloted air systems, especially small multi-copters, have become ubiquitous and analysts expect even further growth. Drone Industry Insights (DII) forecasts a market worth \$54.6bn by 2030, while market research agency Fact.MR has an even bolder prediction: a \$223bn market by the end of 2034. More commercial drones mean

that their safe integration into our skies and changing public perceptions will be ongoing issues.

Applications

DII lists six broad use cases for commercial drones: mapping/surveying, inspection, photography/filming, delivery, tracking and spraying/dispersing. According to DII's most recent Global Drone Industry Barometer, drones performed 7.6 million

o-o-door



flying hours worldwide in 2023. Mapping/surveying accounted for much of the total – 37% among business internal services (BIS) operators (ie, companies with their own drones) and 33% among drone service providers (DSPs).

DII stated: “Photography and filming secure the second position for both types of companies, contributing to 31% of BIS activities and 27% of DSP engagements. Notably, DSPs exhibit a higher utilisation

of the inspection method compared to BIS companies in various industries, with inspections accounting for a 25% share among DSPs and a 16% share among BIS firms.”

Drone use cases have flourished in multiple industries, including precision agriculture, aerial filming, industrial maintenance, infrastructure monitoring, insurance surveys, mining/quarrying, emergency services, security and

telecommunications. As commercial drone usage has blossomed, so has an extensive ecosystem of hardware, software and service providers, payload developers, data analysts, training organisations, and other assorted specialists.

Sophisticated software programmes, such as Swiss company Pix4D’s professional photogrammetry solution, have blossomed. These create 2-D georeferenced visualisations/maps and



“The UK’s Civil Aviation Authority (CAA) plans to authorise routine drone BVLOS operations by 2027”

3-D models using data captured by drones, generating insights such as land surveys or infrastructure condition reports.

Aerial delivery

Cargo transport is another notable use case. The US logistics company Zipline announced in April 2024 that it had completed one million commercial drone deliveries (transporting ten million individual items) to customers worldwide, with 70% of those flights made since 2022. Zipline delivers goods for Walmart in the US, agriculture and animal health products in Africa and food in Japan. Fresh produce is the company’s most frequently delivered item in the US.

The company says its latest Platform 2 (P2) ‘on-board perception system’ is “expected to serve more than 30 million people in ten states within the United States over the next few years.” Zipline recently announced that Panera Bread, Memorial Hermann Health System and Jet’s Pizza plan to use P2 to deliver products in the greater Seattle, Houston and Detroit metro areas, respectively.

On July 30, 2024, the US Federal Aviation Administration (FAA) authorised Zipline and another company, Wing Aviation, to deliver packages by drone while keeping their systems safely separated from other aircraft using unmanned aircraft system traffic management (UTM) technology. An FAA statement said: “Using UTM services, companies can share data and planned flight routes with other authorised airspace users. This allows the operators to safely organise and manage drone flights around each other in shared airspace. All flights occur below 400ft altitude and away from any crewed aircraft. The FAA expects initial flights using UTM services to begin in August [2024] and issuing more authorisations in the Dallas area soon.”

These approvals are part of a wider process of expanding commercial drone use in the US.

Towards BVLOS

The FAA publishes a Notice of Proposed Rulemaking (NPRM) whenever it intends to introduce a new regulation and is working towards releasing an NPRM for drone operations beyond visual line of sight (BVLOS). On July 30, 2024, the FAA said it was on track to release the NPRM this year. The agency noted that drones represent a very different type of aircraft than traditional commercial aviation, and





CLOCKWISE FROM ABOVE:

Orsted is transporting cargo from a vessel to all 94 wind turbines in its Borssele offshore wind farm in the North Sea Orsted

The UK Space Agency-funded CROFT project will explore how space-based 5G services can support drone operations in rural areas Skyparts Drone Services

A Windracers ULTRA photographed in Antarctica early in 2024. The system can carry 100kg payloads up to 1,000 miles Windracers

Windracers says its ULTRA is "designed to be the 'jeep of the skies'" Windracers

The Sustainable Aviation Test Environment project in Orkney explores how a commercial drone service can transport payloads reliably to remote communities, cost-effectively and sustainably Windracers

the FAA's approach to this new NPRM has evolved accordingly: "Industry has created the market and technology, and the agency has worked with them on creative solutions to ensure operations can be done safely. UTM services are a clear example of this innovative approach. The NPRM has been designed to allow operations to scale with the size of the industry."

Unrestricted operations in the US National Airspace System alongside crewed aircraft will be pivotal in commercialising drones. However, it remains to be seen exactly when civil BVLOS will become an everyday operational reality. An 18-24-month time lag between NPRM publication and implementation is typical. For instance, the NPRM for the FAA Part 107 Certificate,

required to pilot unmanned systems in the US National Airspace System, was published in February 2015, but the regulation did not come into effect until August 2016.

Meanwhile, the UK's Civil Aviation Authority (CAA) plans to authorise routine drone BVLOS operations by 2027. A March 2024 Department for Transport action plan said: "BVLOS operations will be routine across the country, using significant blocks of controlled, uncontrolled and service-supported airspace."

The DII Global Drone Industry Barometer 2023 reflected: "Regulatory obstacles continue to pose significant challenges for the drone industry, with rule-making authorities identified as the top market-driving factor."

Remote communities

Using drones for time-sensitive deliveries – for example, PPE, medicine or emergency equipment such as defibrillators – has become increasingly common. Among numerous examples, Skyfarer partnered with University Hospitals Coventry and Warwickshire NHS Trust and Medical Logistics UK from October 2022 to March 2023 to explore drone use for ad-hoc medical deliveries between the trust's sites. And Swedish company Everdrone has undertaken projects with authorities in the region of Västra Götaland in Sweden, the Air Ambulance Charity Kent Surrey Sussex and the Greater Copenhagen Fire Department.

The Scottish Highlands and Islands have become a focal point for commercial

drone delivery trials. In 2023, Orkney became the first UK location to receive mail by drone under the three-month Orkney I-Port Project. Loganair flew letters and small parcels from Kirkwall to Stromness before Skyports Drone Services transported the cargo to Royal Mail staff on the islands of Graemsay and Hoy, where postal workers carried out their usual delivery routes. Skysports recently announced the trial with the Royal Mail in Orkney will continue to at least 2026.

In July 2024, a new UK Space Agency-funded project called CROFT (Connectivity for Remote Orkney Future Transport) was announced. This 22-month project will bring together Skyports Drone Services, Satellite Applications Catapult, Stratospheric Platforms Ltd, Cranfield University and West Midlands 5G to explore how space-based 5G services can support drone operations in rural areas. Also in July 2024, Argyll and Bute Council announced a partnership with Skyports Drone Services to conduct drone demonstrations with the Royal Mail, NHS, Network Rail and Scottish and Southern Electricity Networks to explore further how drones can benefit remote communities.

Wind turbines

The commercial drone sector includes small

systems transporting light cargo as well as relatively larger systems carrying more substantial payloads.

In August 2024, Ørsted announced that drones were transporting cargo from a vessel to all 94 wind turbines in its Borssele offshore wind farm in the North Sea. Building on previous trials, including one off Hornsea in the UK, Ørsted uses a 70kg, 2.6m-wingspan drone to transport 100kg payloads of critical evacuation and safety equipment to each turbine.

The drone flies back and forth from a supply vessel directly to the top of the nacelle on each turbine. Ørsted says delivery flights take about four minutes per turbine, which, a company statement said, will enable deliveries to be completed “10-15 times faster” than the traditional method using vessel transport. It will also improve operational safety, reduce downtime and minimise the need for multiple journeys by ship.

Windracers ULTRA

The Windracers ULTRA (Uncrewed Low-cost Transport), described by its manufacturer as a “low-cost self-flying cargo aircraft”, is a larger fixed-wing civil drone in action. The Southampton-based company told *Air International*: “Windracers has moved quickly from a concept aircraft that has

flown notable missions in the UK into a fully developed business that is manufacturing at scale. Windracers operates on three continents and delivers missions in core use cases – deliver, drop and detect – in a wide range of environments.”

To achieve greater autonomy, Windracers has partnered with Purdue University AIDA and the University of Bristol to incorporate swarm technology. A spokesperson explained that it focuses on “increasing reliability at scale while lowering the cost of operation, building in greater levels of autonomy in our operations, including swarm capability, and optimising to have best-in-class multi-mission capability.” The company has implemented an automotive manufacturing approach to achieve the required levels of quality, reliability and low cost: “Windracers ULTRA has been designed to be the ‘jeep of the skies’, and we continue to improve ULTRA in this way as we encounter new use cases from customers and prospects. Windracers is now testing the third production version of Windracers ULTRA.”

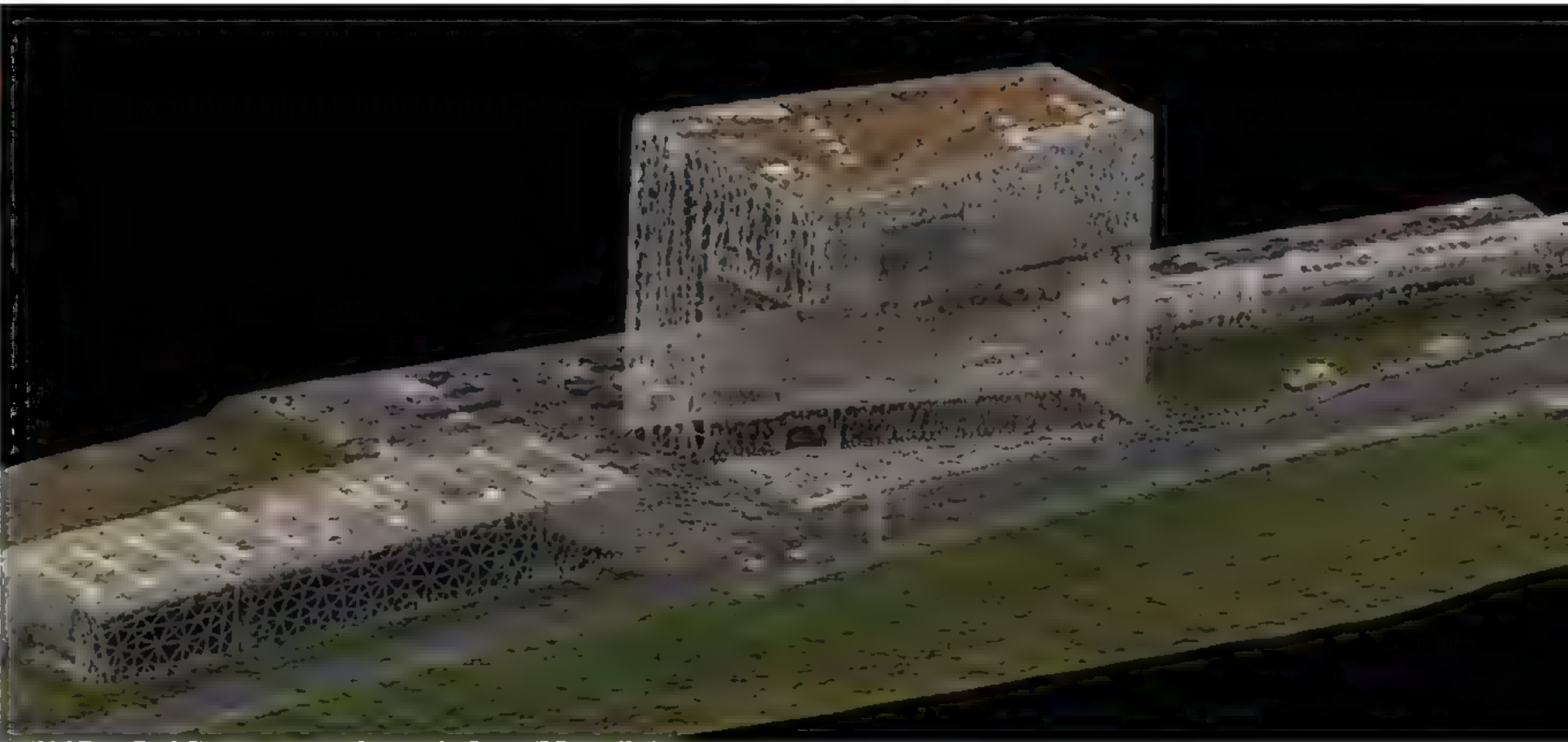
Windracers is also involved in another Highlands and Islands project: the Sustainable Aviation Test Environment (SATE) at Kirkwall, which is described as “the UK’s first operationally based

CLOCKWISE FROM TOP RIGHT:
From January 2025, the Schiebel Camcopter S-100 system is part of the UKSAR2G contract. The system was tested in the UK in 2019
Schiebel

The extensive commercial drone ecosystem includes operators, hardware, software and service providers, payload developers and analysts
Everdrone

Software programmes create 2-D and 3-D models using data captured by drones to create insights for end users
Pix4D

Aerial imagery from drones is used for surveying, inspection and condition monitoring
Pix4D





low-carbon aviation test centre." Part of the UKRI Future Flight Challenge, SATE explores how a commercial drone service can reliably, cost-effectively and sustainably transport payloads to remote communities. In summer 2024, an ULTRA will operate autonomously in segregated airspace on scheduled cargo services in Orkney.

ULTRA has also been used much further afield: the British Antarctic Survey trialed the system in its most recent polar scientific research flight campaign from January to March 2024.

UKSAR2G

Another UK commercial drone use case



is the new, ten-year Second-Generation UK Search and Rescue Aviation service (UKSAR2G) provided by Bristow Group for the Maritime and Coastguard Agency (MCA). Under the UKSAR2G contract, which starts in September 2024, a Schiebel Camcopter S-100 system – two aircraft, a ground control station and engineering and logistics support – will be based at Lydd Airport in Kent, although it will be deployable nationally. According to the latest Department for Transport information, the system will become operational in January 2025.

Bristow first tested an S-100 system in the UK in 2019 in a proof-of-concept trial in North Wales to prove the utility of uncrewed aviation in SAR. The company stationed a second S-100 system at Lydd in 2022 to support MCA and HM Coastguard operations in the English Channel.

Introducing the Camcopter as a permanent asset in the UK is part of a phased roll-out of UKSAR2G over the next two years that will eventually see 18 helicopters – comprising Leonardo AW139s and AW189s, as well as Sikorsky S-92As – along with six Beechcraft King Airs operate from ten bases around the UK, supplemented by two seasonal bases.

Global challenge

More systems in civil skies and expanding use cases mean public awareness and encouraging acceptance is high on the

drone industry's agenda. According to the DII Global Drone Industry Barometer: "Many experts who have talked to average citizens are familiar with the privacy and noise fears that some people immediately associate with drones, and it will be a continued global challenge to educate society on why these concerns are often exaggerated and unnecessary."

The UK Information Commissioner's Office (ICO) notes: "As drones become more widespread and present in our day-to-day lives, concerns around their privacy and data protection implications are likely to become more prominent." According to the ICO, the 'bird's eye' nature of drone operations "raises further concerns about transparency and facilitating people's rights, including the right to be informed if their personal information is being processed."

The ICO said "broader concerns remain" over drones inadvertently collecting personal information: "Complying with transparency requirements and conveying appropriate privacy information to people at the right time may be challenging due to the mobile nature of the drones themselves." The organisation views it as "critical" "that regulators and industry engage to establish policies and standards about personal information collected by drones. This will provide commercial operators with regulatory certainty and increase consumer trust in commercial drone operations." **AI**



As the latest Farnborough International Airshow starts to fade into memory, what is the show's future? **Alan Dron** examines the options



Farnborough in safe hands



CLOCKWISE FROM TOP LEFT:
Embraer displayed the E195-E2, which has firm orders for 2,200 E-Jets, making it the third most successful aircraft in the industry
 All images via Farnborough International Airshow (FIA)

Figures released by ADS Group (the UK trade association for the aerospace, defence, security, and space sectors) the show an estimated total of \$105bn of commercial deals had been signed during the show

Prime Minister Sir Keir Starmer made a firm commitment to support the aerospace sector at Farnborough

The main entrance, to the show, saw a steady flow of visitors throughout the week

The aisles in the exhibition halls were as packed as always, the queues for shuttle buses from the local railway station were as long as usual, and commercial deals totalled more than US\$105bn.

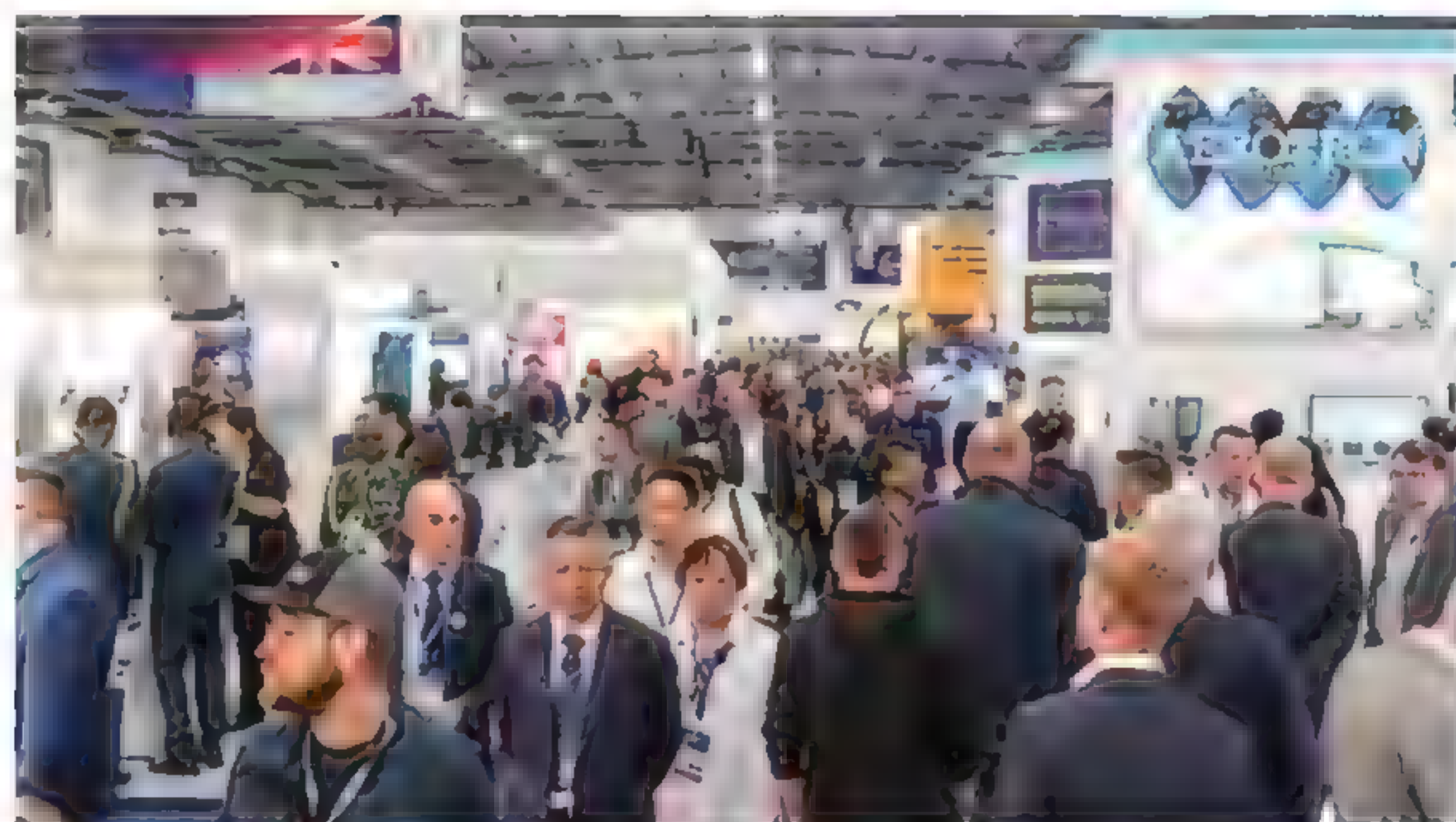
Despite all the positives, however, journalists covering the 2024 Farnborough show felt that it was unusually 'flat' and that it somehow lacked that intangible buzz that one expects at such events.

There were a few apparent factors behind this. Boeing – trying to recover its equilibrium following multiple revelations about quality problems both in its supply chain and on its own assembly lines

– had telegraphed a couple of weeks previously that it would be adopting a low profile at the show, focusing on safety, quality, and next-generation technologies.

With that in mind, for the first time in living memory, Qatar Airways brought no demonstrator airliners to the show (Qatar Airways contributed a solitary 787-9 to the static display). Although it did announce some orders at the event, several were merely confirmations of previously announced letters of intent or memoranda of understanding.

Airbus, notably, did not seek to take advantage of its rival's chagrin. At a press briefing on the eve of the show, the European airframer's Commercial Aircraft CEO, Christian Scherer, pointedly



THIS PAGE, CLOCKWISE FROM TOP:
The RAF sent an F-35B to appear in the flying display on Monday and Friday at FIA2024

The display halls and exhibitions were busy throughout the week

More than 100 companies have already rebooked for the 2026 Farnborough International Airshow

The British summer came out for Farnborough week, allowing many visitors and delegates to watch the daily flying display in comfort

US-eVTOL aircraft developer Joby showcased its aircraft for the first time in Europe at Farnborough. The full-scale replica was the first time Joby had brought the full-scale aircraft to the UK, and attendees could explore the cabin interior

remarked: "What happens at Boeing is, at best, a healthy reminder to us of the things that you don't take your eyes off." In other words, This could happen to any of us.

And major commercial aircraft deals for Embraer, which the Brazilian manufacturer had previously hinted at, failed to materialise in time for the five-day extravaganza in Hampshire.

In addition to these disappointments, the static display was notably dull. The only 'new' aircraft on display was the Embraer E190F freighter conversion.

Some of these factors were outside the show organisers' control – new aircraft models are few and far between these days. At the same time, order announcements are notoriously prone to last-minute glitches. On the positive side, there was military interest in a significantly revised Global Combat Air Programme, the sixth-generation fighter aircraft being developed by Italy, Japan and the

UK, while Advanced Air Mobility (AAM) designs, the small, electrically powered 'air taxis' that business executive and affluent holidaymakers will apparently be using ten years hence, could be seen everywhere.

The UK's new Labour Party government also demonstrated its regard for the show by having the prime minister and several ministers attend the event.

Despite all this, however, the whole week somehow felt indefinitely 'flat'.

Of course, there are some longstanding gripes about Farnborough. Foreign executives, for example, find it irritating to have to make the 45-mile hack down from central London, either by corporate minibus or on standing-room-only trains from London Waterloo, and then rush back at the end of the day to host social events in the capital.

The Farnborough show is already changing. It has cut the traditional weekend public days – probably to the

relief of exhibitors, who gained little benefit from having thousands of families, rather than business executives, milling around the stands, but had the cost of requiring personnel to staff their exhibits. In recent years, there has inevitably been an increasing stress placed on sustainability as a counter-balance to commercial aviation being a high-profile target for environmental campaigners.

Possible further changes? Suggestions exist that the traditional daily air display will also be dispensed with in the future. Some people believe that fast passes and pirouettes still help to sell aircraft, but many executives (and journalists) would

appreciated the opportunity to talk to the government directly, in-person, then having to go through the usual process to get advice and support."

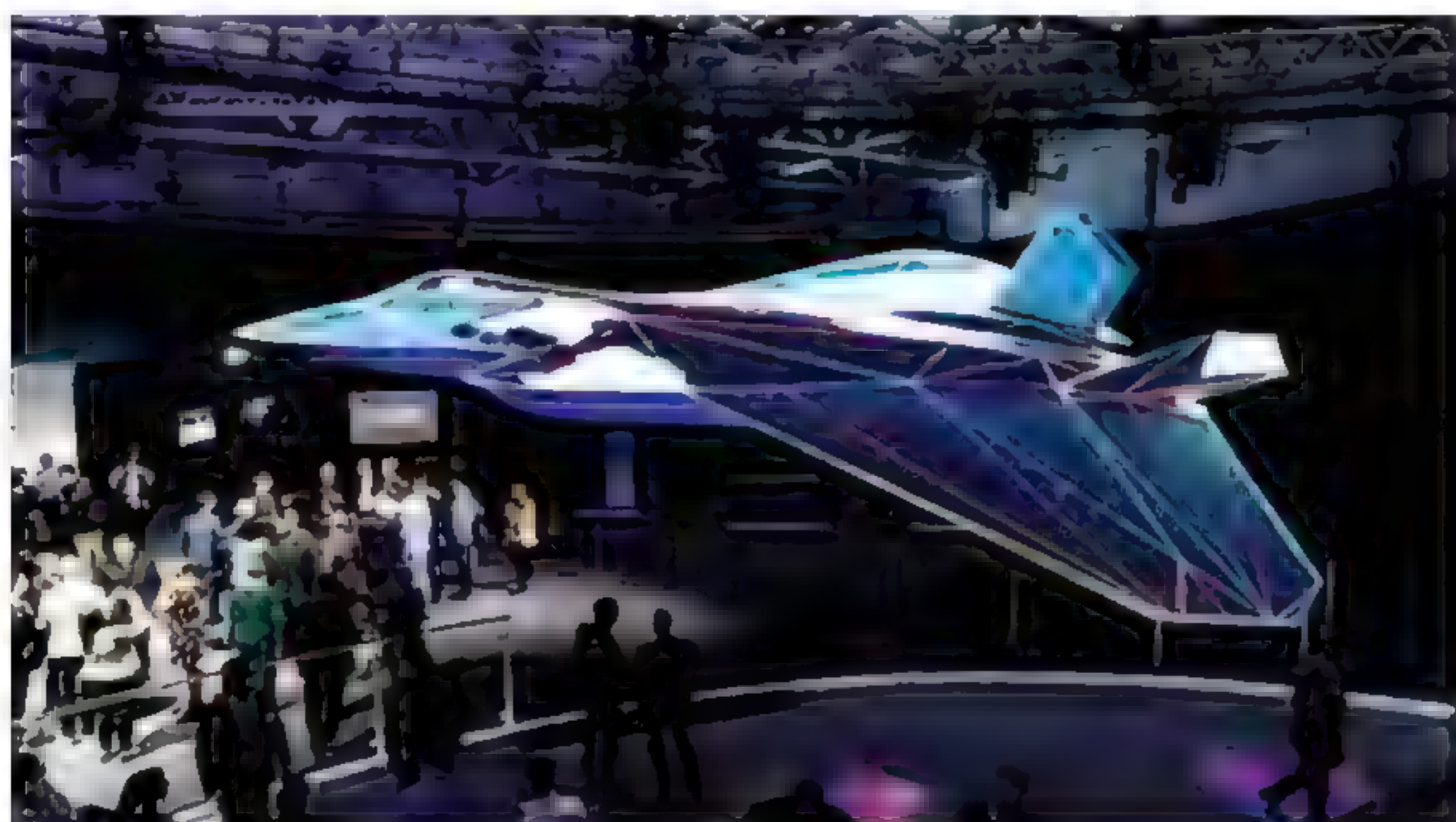
Importantly, he added, on the last day of the show, there was a jump in participation in addressing the industry's ongoing skills shortage and the now-traditional efforts to attract future aerospace industry personnel. "More than 20,000 public spent the day with us and engaged in the STEM-focused and future workforce activities our exhibitors laid on. This was the busiest Pioneers of Tomorrow event we have held, and the engagement from our exhibitors

and hosts more national exhibitors at their event, which naturally draws more national visitors and families across the show.

"We are keen to not be solely focused on the commercial deals aspect of the industry; our vision and aim has been to position the event as a catalyst for thought leadership, international relationships and innovation across aerospace, defence, and space."

In general, what does he see as being the show's future?

Perhaps unsurprisingly, he is bullish. "The future is bright. Innovation is at the heart of what we do and want to be



happily forego business meetings and press conferences interrupted by the ear-splitting roars of military jets on full afterburner.

With this as background, the show's organisers are bullish both about this year's show and that in 2026.

According to Joe Muir, Farnborough International's aerospace commercial director, this year's edition "exceeded all expectations across the board. The event was sold out in advance of the show with a waiting list for the first time in over a decade, which reflects how the industry views the airshow as an important platform for business.

"Our new Government Hub was a welcome addition to the show, demonstrating the importance that His Majesty's Government placed on the show, which clocked up thousands of visitors. Featuring 10 different government departments and agencies...visitors

showcased its importance and value for them to inspire careers in the sector."

Some statistics: The organisers said post-show that it had been the busiest event in recent decades, with a 33% increase in visitors and a 57% increase in delegation attendance compared to 2022. Across the week, more than 100,000 visitors passed through the gates (compared to around 80,000 in the immediate post-COVID show of 2022), 1,500 exhibitors from more than 60 countries, and 90 civil and military aircraft.

But how does Farnborough compete with Paris, which typically pulls in more than double the number of visitors than Farnborough?

"Each airshow has its own focuses, strengths and legacies as to why they are successful," said Muir. "There is a huge demand for two major airshows in the industry.

"Paris Airshow offers two public days

THIS PAGE, CLOCKWISE FROM ABOVE:

Mike Kane, MP, Parliamentary Under-Secretary of State (Aviation, Maritime and Security Minister), was present at FIA2024 and was keen to discuss the UK's technological role in future aviation in all sectors

Aerospace deals confirmed at the show included 260 firm aircraft orders worth £6.4bn for the UK and 808 firm engine orders worth another £1.2bn to the UK at current prices

A revised configuration to the Global Combat Aircraft Programme was unveiled at the show, causing considerable interest amongst the defence media present

The Dutch Ministry of Defence signed a contract to acquire nine Embraer C-390 Millennium aircraft during a ceremony at Farnborough. The contract is a joint purchase with Austria, five for the Royal Netherlands Air Force and four for the Austrian Air Force, as part of the project 'Replacement of Tactical Airlift Capacity'

known for, so we are looking to keep improving our features, launch new ideas into the market and work in partnership with the industry to ensure we continue to meet the needs of our customer deliver what they need as a platform to reach their objectives.

"The feedback from industry following the airshow highlights aircraft displays, thought leadership forums and interactive features as important parts of what makes FIA [a] success.

"It was very clear from this year's flying display that they are still extremely important and are powerful commercial and political tools. Flying displays demonstrate so much, particularly soft power, innovation and national pride. The feedback we have received from

And "The broader recognition of aviation's environmental effects may reduce the enthusiasm of some companies to take part in a big air show.

"Related to this, attacks by environmental protestors at [business jet show] EBACE and elsewhere may have made some OEMs nervous about displaying their aircraft in such a 'low-security' environment. I know that both Bombardier and Gulfstream pulled out of EBACE this year, preferring to focus on smaller (and more secure?) events. I could imagine a similar dynamic at Farnborough."

But Neil Fraser, manager of airline analysis at consultancy IBA, takes a more positive view of the show's future, believing it will remain relevant.



CLOCKWISE FROM TOP LEFT:

Dedicated zones within the display halls proved popular with the attending specialist media

Farnborough International Airshow 2024 was, from an aircraft point of view, somewhat smaller than previous years

Plans are already in the works for Farnborough 2026, which will once again welcome the return of the aviation industry

A wealth of briefings by leading OEMs occurred throughout the week

our customers is that they are one of the most important tools to demonstrate their products."

Opinions of neutral observers as to the show's validity vary.

"I was at FIA this year and concur with the sense that it was not a vintage year," said Patrick Edmond, head of aviation consultancy, Altair Advisory.

There were several factors behind this.

"Boeing's difficulties mean that the Boeing/Airbus rivalry is not as keen as before, which impacts the number of aircraft on display, the excitement over big order announcements, and so on.

"The main OEMs have no major civil aircraft development projects going on (I am not counting the Comac C929!), so there is no excitement around supplier selection, etc."

"I think Paris will always be a bigger show than Farnborough. You're always going to have that 'home bias' with Airbus.

"There's various elements of politics and diplomacy going on with various airshows. Singapore and Dubai are said to be challenging Farnborough. [But] Singapore has never been that big. And at Dubai...in terms of commercial aviation, you're not going, for example, to get Qatar making an order in Dubai.

"And Flynas [announced an order] at Farnborough because Saudi Arabia similarly don't want to celebrate an order in Dubai." On the other hand, Europe is seen as neutral ground where large orders can be announced, he said.

"I think Farnborough is here to stay for a while. There's still definitely demand for it." **AI**



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Will it be blue skies or stormy skies for *Tempest?*

Against the backdrop of a looming UK defence review and tight budgetary pressures, the tri-national Global Combat Air Programme (GCAP) and the associated next-generation Tempest manned combat aircraft concept loomed large at this year's Farnborough International Airshow. **Jon Lake** reports

BAE Systems unveiled a new, full-sized model of the latest GCAP concept at Farnborough, setting the scene for a show that often seemed dominated by discussions about the programme and the aircraft.

To brief the press, the GCAP consortium rolled out the programme's 'big guns' from across the UK, Italy and Japanese industry partnerships. BAE Systems' managing director of Future Air Combat Systems, Herman Claesen, was joined by Leonardo's Guglielmo Maviglia (chief Global Combat Air Programme officer) and Mitsubishi Heavy Industries'

Hitoshi Shiraishi (senior fellow, GCAP). The three spoke with one voice, praising the power of the trilateral collaboration and highlighting the operational advantages of having a genuinely sovereign freedom of action and freedom of modification – key to keeping pace with a rapidly evolving threat, as well as offering considerable industrial and economic benefits.

All insisted that a manned platform was the essential element driving the 'system of systems' that will provide next-generation combat air capabilities. They said only GCAP would deliver the military capabilities, strategic relevance and sovereignty and prosperity advantages needed by the three partner nations.

What's in a name?

Tempest is the UK name of the manned combat air platform (also called a fighter) that is intended to sit at the heart of the FCAS (Future Combat Air System) 'system of systems'. That 'system of systems' will see Tempest operating alongside unmanned 'adjuncts' (UCAVs, in old money) and 'effectors' (weapons and non-kinetic systems). It is also the name used by the team that created it ('Team Tempest').

The Tempest aircraft is being produced under the tri-national Global Combat Air Programme (GCAP). Italy and Japan will produce their own 'systems of systems' and may or may not adopt the



Tempest name. A quite separate Crewed Combat Air Demonstrator (previously known as the Flying Technology Demonstrator) is not a Tempest prototype. Still, it will be used to develop both technologies and the SQUEP (suitably qualified and experienced personnel) that the GCAP programme will require. Air Commodore Martin Lowe, the MOD's FCAS programme director, was at pains to tell *Air International*: "It's not a prototype in terms of shape or size!" Following the Tornado, Typhoon and now Tempest, it would be a missed opportunity not to name the new demonstrator as the Hurricane.

Moving on to the Tempest/GCAP proper, the new concept shown at Farnborough bore some resemblance to the previously seen P.189-17B, and especially to the refined configurations shown at DSEI Japan and the refined model seen at the World Defence Show in Saudi Arabia. The new model had the same trapezoidal

swept delta wing."

Sweetman noted that GCAP is a "long-range fighter that far better suits Pacific (and Australian) distances than aircraft now available" and that it will become the mainstay of Japan's combat air force. Sweetman even speculated that "the stealthy aircraft is also a clear candidate as Australia's next fighter." But in truth, GCAP is simply the first aircraft not designed for the relatively constrained ranges required in Cold War Europe (and subsequently in the 1991 Gulf War), and longer ranges and longer endurance are not unique to Pacific requirements.

No dimensions were given, and measuring the various models was discouraged. Still, analysis of photographs, coupled with the measured and uniform stride of one ex-military officer, allowed *Air International* to guesstimate a fuselage length of just under 65ft and a wingspan a smidgeon below 54ft, with a leading-edge sweep of

know a thing or two about high-speed performance. Meanwhile, the innovative powerplant being designed by Rolls-Royce, IHI and Avio Aero may incorporate exactly the variable cycle technology best suited for supercruise.

Sweetman concluded that "the design seen at Farnborough suggests that the requirement has been well thought through. It's a promising start".

BAE Systems' Herman Claesen was unwilling to discuss the concept model but explained the size and broad configuration: "I'm not going to give you details, for obvious reasons, because this is classified information. But I think most of you will have spotted that if you look at any other sixth-generation development out there, they all tend to go for that kind of shape, that kind of size. And what does that mean? Well, you need to go far. You need to carry lots of stuff and do it in a low-observable, stealthy configuration. So, you don't need to be an expert – I think

CLOCKWISE FROM TOP RIGHT: Britain's new Prime Minister, Sir Keir Starmer, see here with Dr Charles Woodburn, Group Chief Executive Officer of BAE Systems

The latest GCAP concept has low observability at its heart, with more internal volume for fuel and payload than today's fifth-generation platforms

Jon Lake

The refined GCAP concept show at Farnborough has significantly more wing area than previous GCAP and Tempest models, promising low drag and high lift

Jon Lake

The BAE Systems Hall at Farnborough was dominated by a life-sized 1:1 scale model of Tempest/GCAP, onto which various logos and graphics were projected. Over 1,000 suppliers are supporting the programme across three nations

Jon Lake

PREVIOUS PAGES: The partners say that they are rapidly homing in on the final configuration, but what makes GCAP a potential world-beater is what goes inside. Leonardo gave a little more detail about sensor integration at Farnborough

Leonardo



twin fins and the same forward-swept intakes, and the same wing leading-edge sweep. However, the model shown at Farnborough represented what the company called "a more evolved design than previous concepts with a larger wingspan and improved aerodynamics". In particular, the previous 'arrow-like' trailing edge shape has been 'filled in', giving the aircraft a massive Delta wing.

Noted analyst and author Bill Sweetman observed: "BAE Systems and its Global Combat Air Programme partners pulled off a coup of technology theatre at the Farnborough air show in July, unveiling a new design for their GCAP fighter, in full-scale model form, that looked very different from any other existing or proposed aircraft. Surprises for the combat aircraft community included the aircraft's size, much larger than the Typhoon or F-35 fighters, and a quite enormous, moderately

perhaps 48-50°. This is broadly the size of the F-15E, albeit the span is nearly ten feet greater. Tempest's wing area has been calculated to be almost twice as large as that of the aircraft whose wing was once compared to a tennis court!

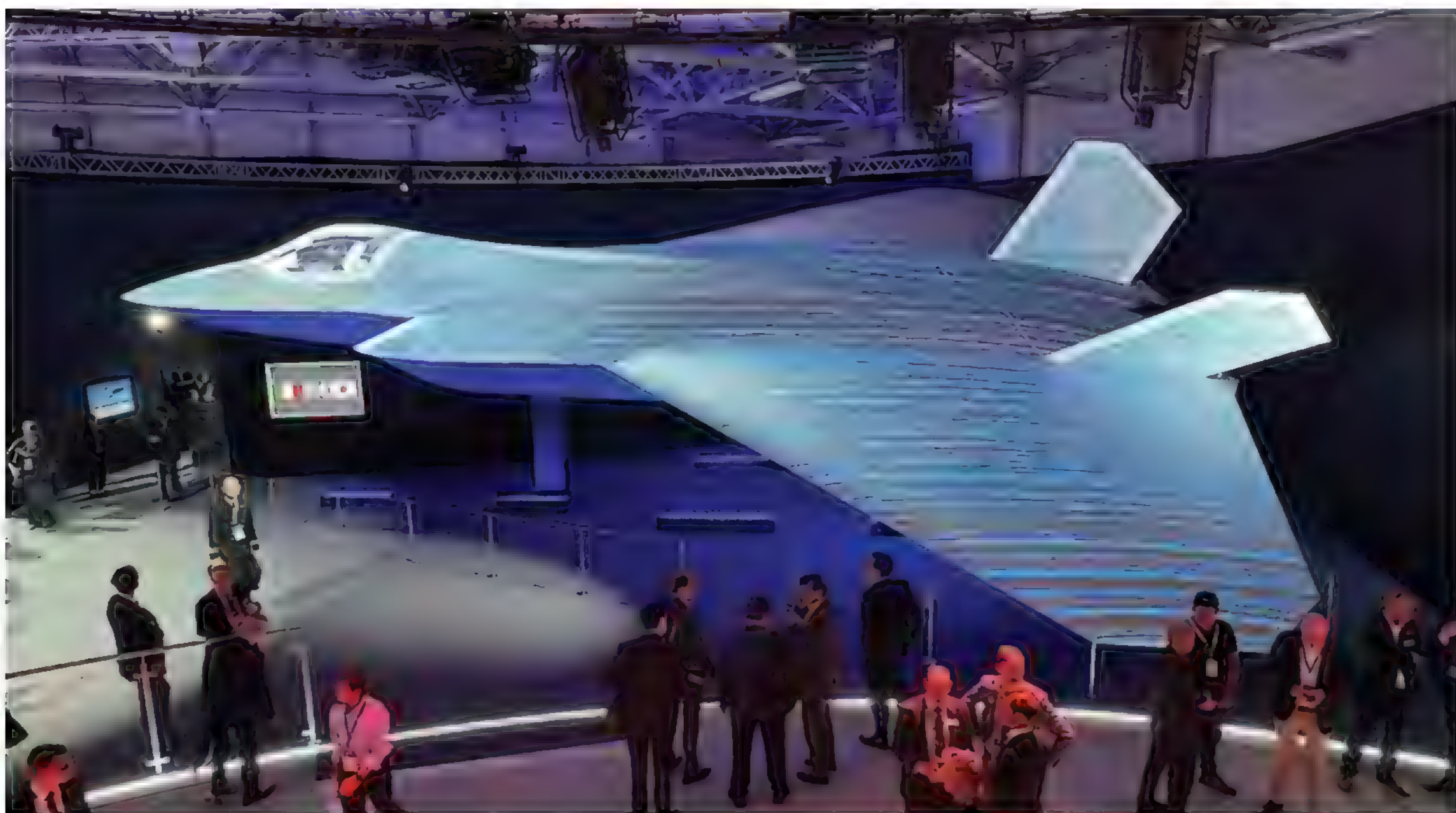
The wing (which Sweetman compared with those of the F-16U and the X-32) promises good turn performance, massive internal fuel volume and low drag in cruising flight. This could give the Tempest a longer combat radius on internal fuel than most current combat air platforms can achieve with external fuel tanks. It may also confer an unusual degree of agility for an aircraft that is so large.

Sweetman opined that the wing leading-edge sweep angle did not "seem to be optimised for supercruise", but many others disagree and counter that the company responsible for Typhoon (and Tornado F.Mk 3 before it) might

any aerospace engineer will quickly get you into that kind of configuration. So, it's about the refinement, about making sure the low observability characteristics and performance is achieved as best as you possibly can."

Perhaps the first thing to say is that the aircraft that does eventually enter service in 2035 may look nothing at all like the model displayed at Farnborough or illustrated in dozens of GCI artworks and videos. This is not just because some details of the current concept have been 'finessed' for security reasons (though they have). Rather, the aircraft on show at Farnborough represents no more than a 'snapshot in time' – an illustration of what UK concepting to date shows would (or perhaps more accurately could) meet today's UK requirement.

Digital techniques (including computational fluid dynamics) allow



concepting at an almost unimaginable pace, and the Tempest project has already seen many configurations being assessed and analysed, and the trilateral concepting and assessment phase (scheduled for 2021-2025) still has some months to run. Claesen told *Air International*: “We’ll continue to test and evolve the design, as we move closer towards the next phase of the programme.” Moreover, the full trilateral joint design and development phase, which marks the full launch of the design and development activities, will not begin until next year, and will run until 2035 – only then will Italian and Japanese requirements start to shape the design.

And yet, at the same time, there have been hints that we may be closer to seeing a definitive GCAP design than has sometimes been realised.

When acknowledging that the full launch of the design and development activities

is not due to start until 2025, Claesen was quick to point out that real progress had already been made: “Does that mean that we’re not doing anything today? No, we each have a significant number of engineers in each of our countries who are co-creating and collaborating. I now permanently have people based in Japan and Italy and vice versa, working on the components of the aircraft.

“We have one requirements document. All the requirements managers from the three countries have established one single set of requirements, and our engineers are currently concepting against that requirement set. You can see a physical product outside.

“We are rapidly homing-in on the final configuration, and as we call it, the outer mould line of the aircraft is always one of the big milestones that we need to be achieving. But as I keep repeating, it’s not

just about the product. It’s not just what it looks like. It is what goes inside.”

And what goes inside received further exposure at Farnborough, where Leonardo gave new details about sensor integration on Tempest/GCAP.

ISANKE/ICS

Team Tempest was once limited to saying only that the aircraft would have an Integrated Sensing And Non-Kinetic Effects and Integrated Communication System (ISANKE/ICS), but was not allowed to detail exactly which sensors were to be integrated, such were the security constraints imposed. This was frustrating, as it is the deep integration of these sensors that qualifies Tempest for the ‘sixth-generation’ tag, and that will enable allied air forces to quickly and accurately locate targets and deny surveillance technology operated by adversaries. ➡

Recently, the rules have been relaxed, and at Farnborough Leonardo showed an interactive model that illustrated how the sensors are integrated and how Tempest could operate within a wider system of systems.

Instead of using separate sensors, Tempest will have a fully integrated fused sensing capability. This will give the Tempest pilot an enhanced view of the battlespace providing an unparalleled situational awareness picture, maximising survivability.

ISANKE has been compared to a 'spider's web' of capability sitting across an aircraft, with integrated systems rather than distinct pieces of equipment. Leonardo has described some of the elements within ISANKE-ICS, which promise to unlock the full potential of sixth-generation sensing. The MRFS (Multi-function Radio Frequency System) will provide capabilities beyond those generally associated with a traditional radar, collecting and processing unprecedented quantities of data (claimed to be equivalent to the internet traffic of a large city). The Infrared and Electro-Optical System combines Infra-Red Search and Track, Electro-Optical Targeting and Distributed Electro-Optical Systems, providing passive detection and tracking of threats.

While ISANKE will allow Tempest to

better detect future threats from air, land and sea, Tempest's Integrated Communication System (ICS) connects the ISANKE system to the broader FCAS system of systems. ICS includes vehicle and tactical datalinks with beyond line of sight (BLOS) capabilities. The system will dynamically self-optimize to operate to the best advantage in any given tactical situation and enable ISANKE to operate as an adaptive mesh across formations of widely separated manned and unmanned aircraft.

The ISANKE system will also incorporate significant electronic warfare capabilities, making it more resilient in tomorrow's congested and contested battlespace.

GCAP origins

The GCAP programme owes its existence to separate but parallel efforts to develop a next-generation fighter aircraft in the UK and Japan. In the UK, development of what would become Tempest began in 2015 with the Future Combat Air System Technology Initiative. This followed the 2010 cancellation of the earlier DPOC (Deep and Persistent Offensive Capability) requirement, which had aimed to produce a Tornado replacement.

The UK defence ministry launched the similarly named but unrelated four-year Future Combat Air System (FCAS) study in 2012 to examine future unmanned combat



CLOCKWISE FROM TOP RIGHT:
Some have suggested that the size of GCAP may indicate that performance and agility have been sacrificed. This is not the case, though the aircraft does have a payload, range and formidable sensing capabilities
BAE Systems

Paul Wilde, Head of Tempest at BAE Systems and Air Commodore Martin Lowe, Future Combat Air Systems Programme Director for the UK Ministry of Defence, briefed selected journalists on the Crewed Combat Air Demonstrator project
Jon Lake

The Crewed Combat Air Demonstrator is in build, with more than half of the airframe by weight now in assembly. Innovative materials and manufacturing processes hold the promise of rapid progress
BAE Systems

air systems. In November 2014, FCAS became an Anglo-French unmanned combat aircraft feasibility study, and a number of development contracts were placed. In March 2016, plans were announced for investments of £1.54bn to advance the project to its next stage, but the programme petered out as the two nations slowly began to diverge.

France teamed with Germany and Spain on the FCAS/SCAF programme (another confusing reuse of the FCAS acronym), while the UK published its Combat Air Strategy on July 16, 2018. Key elements



of this Combat Air Strategy included full implementation of the Future Combat Air System Technology Initiative (FCAS-TI, invariably abbreviated to FCAS) launched in 2015 and a study of Typhoon replacement programmes. BAE unveiled its Tempest sixth-generation fighter concept that same day at the Farnborough Airshow.

The new fighter was to be developed by the Team Tempest consortium, with BAE Systems as project leader and systems integrator; Rolls-Royce providing power and propulsion; Leonardo S.p.A. providing sensors, electronics and avionics; MBDA providing weapons; and the Royal Air Force Rapid Capabilities Office (RCO). The launch included unveiling the now-familiar Tempest Full Scale Replica – a fibreglass model of a representative configuration sitting on surplus Tornado undercarriage units, with an over-large cockpit and an unusually deep forward fuselage. Wags immediately dubbed it the ‘Pregnant Pelican’.

It was always clear that the UK would seek international partners for the Tempest programme, to share the costs and provide a bigger ‘order book’ – thereby ensuring economies of scale. Talks with Sweden were reported in 2018, and in February 2019 it was reported that the UK had approached India, offering to collaborate in the design and manufacture

of the Tempest. On July 19, 2019, Sweden and the UK signed a memorandum of understanding (MOU) to explore prospects for joint development of sixth-generation air combat technologies.

Italy signed a statement of intent to participate in Team Tempest on September 10, 2019, with Leonardo Italy, Elettronica, Avio Aero and MBDA Italy joining the programme.

Trilateral industry discussions between the UK, Sweden and Italy had begun by July 2020, and a trilateral Future Combat Air System Co-operation (FCASC) MOU was signed on December 21, 2020. This defined “general principles for co-operation on an equal basis between the three countries”.

But it soon became apparent that Swedish requirements were poorly aligned with those of the UK and Italy, and a new relationship with Japan gradually assumed greater importance.

Japan conducted a future fighter study (with the aim of replacing the F-2) between December 2009 and August 2010. The new i3 Fighter (Informed, Intelligent, Instantaneous) concept was intended to be a generation ahead of then-contemporary fifth-generation fighters, and led directly to the development of the Mitsubishi X-2 Shinshin demonstrator, which made its maiden flight on April 22, 2016.

In February 2019, the Japanese MoD announced that a ‘Japan-led’ FX (or F-3) Future Fighter programme would be initiated, within the ‘Mid-Term Defense Programme’. It was expected to take some 15 years to complete, with service entry in around 2035, in time to replace the F-2. Initially it looked as though the FX might be co-developed with the US, but links with the UK progressively strengthened after Japan and UK signed an agreement in March 2017, setting out the possibility of co-developing a future fighter aircraft. It rapidly became clear that the Japanese and Anglo-Italian requirements were similar, with their emphasis on operating within a ‘system of systems’, long-range, combat persistence, and the need to achieve air dominance in an increasingly contested and dynamically changing threat environment.

The UK and Japan signed a memorandum of co-operation (MOC) in December 2021, enabling both nations to pursue joint technologies and setting up an initial ‘building block’ for co-operation. In December, the two nations also announced their intention to jointly develop a future fighter engine demonstrator as part of their partnership.

On February 15, 2022, the UK and Japan signed a letter of arrangement (LOA) to jointly conduct co-operative research

on a new world-leading universal radio frequency sensor known as JAGUAR.

Designing, building and evaluating the JAGUAR system will take around five years, involving Leonardo UK and Japanese industry. Two demonstrators will be built in each country, with the work and learning shared to maximise national expertise. Technology and learning from JAGUAR will then feed into the development of Tempest's ISANKE-ICS.

The GCAP project began in December 2022, when the UK, Italian and Japanese prime ministers announced the creation of the Global Combat Air Programme, committing to develop a next-generation manned fighter. This would be designed to meet the needs of the 21st-century battlespace, winning and retaining air superiority and delivering a step change in air combat capability. The programme was intended to produce an aircraft that would be at the forefront of technology development for decades.

It was acknowledged that the GCAP aircraft would operate as the core element within a wider system of systems, but that the GCAP programme would be narrowly focused on the core manned platform. For the UK, that core manned fighter would operate within the FCAS family of systems, while Italy and Japan were expected to develop their own wider combat air systems of systems.

The 2021 Defence Command Paper ('Defence in a Competitive Age') had announced a £2bn investment in FCAS and offered a useful definition of what the Future Combat Air System was expected to be: "FCAS will deliver an innovative mix of crewed, uncrewed and autonomous platforms including swarming drones. This will deliver an advanced combat air system capable of fighting in the most hostile

environments. The development of novel technologies and a step change in how we use simulators for mission rehearsal and training will enable the Royal Air Force to be among the most technologically innovative, productive and lethal air forces in the world."

In September 2023, BAE Systems, Leonardo and Mitsubishi Heavy Engineering announced a trilateral collaboration agreement. Then, in December 2023, the British, Italian and Japanese governments formally signed the GCAP Treaty, committing them to establish an international agency that would deliver a next-generation combat aircraft by 2035.

Claesen observed: "You will recall that in Tokyo in December, the three ministers got together and, in effect, laid the foundations and agreed on the content of the treaty that is now actually nearing completion in terms of the treaty ratification by each of the three governments. To be able to deliver that treaty in two years is unheard of. If you look at any other treaties that tend to be established in support of any governmental activities that take multiple years, I think it's taking everybody by surprise, how quickly we managed to get this in place. And that gives you a feel of the energy, the pace, the strategic importance of the programme to make that happen."

The full design and development phase is expected to begin in 2025, with joint government and industry working arrangements. This is planned to lead to service entry in 2035, though *Air International* understands that this will be defined as the delivery of aircraft to the UK's test and evaluation unit, with the OCU (Operational Conversion Unit) standing up 12-18 months later. Some reports suggest that the first Tempest base may be RAF



Leuchars in Scotland.

Claesen said: "By 2035, we expect the first system to be available to our air forces to start the workup for operational readiness. That's the objective. We are still working on the detail with our air forces to determine exactly what that means and what's required. It's not only about the aircraft and the system, but also the supporting equipment on the airfields, back at the main operating bases, and the training. There's a whole DLOD [defence lines of development] infrastructure that needs to be in place. So these discussions are going on to define exactly what that means at that point in time.

"I think the most important thing to highlight here is that, unlike other previous combat aircraft, the philosophy of the design here is based on open architecture, which means it's a lot easier to enhance the capability on the platform. As a result, this system doesn't have an FOC [final





operational capability] date; that's part of the philosophy. It constantly updates and it constantly rolls through the open architecture to keep pace with the threats. And if you look at the threat environment, it's relentless. So for us to design a solution which was quite strict and difficult to change, it's just not sensible in terms of the threats that are out there."

Full-rate production is expected to run from 2035 to '2060+', with simultaneous sustainment and spiral development.

Exports will be a key feature of the GCAP programme, although there is a determination to stick to the planned schedule. This might imply that partners will be welcomed only after workshare arrangements between the three core partners have been nailed down. Participation would seem to be more likely within the wider 'system of systems' than within the core manned aircraft programme.

Claesen said: "If, for whatever reason,

a decision is made to introduce another partner, we will look at that point in time, and take into consideration what the capability is from that respective nation, that's very important as well, and what kind of opportunity there is to integrate any other partner within the programme without affecting the timeline that we're working on. This is a very demanding timeline, and we have gathered excellent pace so far, but we remain open." When specifically asked about the possibility of co-operating with France or Germany, he said: "We're designing the core platform, but there is also an opportunity to work with others on the system of systems." Questions about Saudi involvement were adroitly side-stepped.

Stormy skies ahead?

Even before Britain's General Election, there were questions about the programme's future. Some pointed

ABOVE:

A CGI image of a GCAP fighter flying over Rome. Interestingly, Leonardo's CGI images sometimes show more external detail than similar images issued by BAE Systems

Leonardo

OPPOSITE:

Leonardo's Guglielmo Maviglia (Chief Global Combat Air Programme Officer), Herman Claesen (BAE Systems' Managing Director of Future Air Combat Systems) and Hitoshi Shiraishi (Senior Fellow, GCAP with Mitsubishi Heavy Industries)

Jon Lake



to the US, where the USAF's apparent reduction in commitment to the NGAD (Next-Generation Air Dominance) programme was interpreted as marking a wavering in support for a sixth-generation fighter programme. Did this indicate that there was no military need for such an aircraft, they asked, or that there should be greater investment in unmanned platforms? In fact, the loosening of USAF commitment to NGAD actually marks a budget-driven shift in prioritisation in favour of the B-21 Raider bomber and the LGM-35A Sentinel ICBM – the two legs of the US nuclear triad for which the USAF has responsibility.

Others have argued that Tempest's timescales make it irrelevant against the near-term threat and advocated nearer-term procurement of existing off-the-shelf platforms – notably, the Lockheed Martin F-35A – instead. While there may be a case for investing in near-term capabilities, that must not be at the expense of potentially war-winning capabilities tomorrow.

And while the F-35 does undoubtedly have some 'near term relevance', and is today's 'apex predator', it was designed

for today's epoch. It would be inadequate to operate in tomorrow's more contested and complex environment, except as an adjunct to a sixth-generation fighter like Tempest.

Against the background of a forthcoming defence review in the UK, some hoped that incoming Labour Prime Minister Sir Keir Starmer would explicitly exclude GCAP from the review. When he did not do so, some national newspapers (including the *Times*, *Daily Telegraph* and *Daily Mail*) interpreted this as meaning that the programme could be scaled back or cancelled.

Starmer's supposed failure to give unequivocal backing for the aircraft came after the armed forces minister, Luke Pollard, didn't offer an explicit guarantee that the GCAP programme would be unaffected by the defence review. Saying that Tempest was a "really important programme for us", he also said it was "not right for me to prejudge what might happen in the defence review".

But while Starmer failed to offer cast-iron guarantees for the future of the Tempest/GCAP programme, he publicly said at Farnborough that it was "an important programme, and I know that people in the

room will want to hear me say that". He added: It is a programme on which we are making significant progress, and the defence secretary is holding a ministerial-level meeting next week because of the significant benefits it will bring to this country. There is, of course, a review going on, but it is important for me to put on record just how important a programme this is."

Starmer also made a special effort to reassure GCAP programme personnel, according to Herman Claesen: "There's no toe brakes being applied and the pace continues to go on. Of course, we need to respect the fact that the government has called an SDR [strategic defence review] and wants to look at the priorities and everything that goes with it. But about half-an-hour before this meeting, I had the opportunity to spend five minutes with the prime minister, who came down to the GCAP stand specially. And he reiterated that GCAP is a very important programme for the UK. And so I think the fact that he came out here, wanted to see the aircraft, wanted to talk to people about it, gives another indication that it is a very important,



CLOCKWISE FROM LEFT:

The ambitions of the GCAP team are stoked by the threat picture that the partners are facing. There is a constant 'ratchet of the bar' in terms of the threat and the battlespace which threatens the viability of today's combat air platforms. The GCAP partners are building a complementary platform that will build on the value and competence of the F-35 and that can raise the bar enough to ensure continuing air dominance Leonardo

Hitoshi Shiraishi (Senior Fellow, GCAP with Mitsubishi Heavy Industries) posing with the GCAP model. Japan supported the GCAP effort at Farnborough with its industry executives and even its Defence Minister, Minoru Kihara

Jon Lake

The case for GCAP is compelling, but short-termism and budgetary constraints could threaten progress. One hopes that whoever is responsible for the landing gear draws up something sturdier than the one shown in this CGI image!

BAE Systems



key, strategic programme to the UK. We stand by to support the government on their process. That's a normal part of business. Even if we hadn't had the SDR, we would still have had to provide lots of supporting information for the business case reviews, whether that be economic data, programme data or anything else to support the right decision-making going forward."

No fewer than four Labour ministers visited the GCAP stand at Farnborough, with defence secretary John Healey, Maria Eagle – minister for defence procurement – and business secretary Jonathan Reynolds all following in their leader's footsteps.

But while Tempest/GCAP may be safe, some fear that the FCAS system of systems may not be, and that it could be cancelled in favour of a cheaper, nearer-term, ad hoc purchase of 'off the shelf' effectors. This might also include a buy of adjuncts, though many believe that we are still many years away from a viable, operationally useful collaborative combat aircraft or 'loyal wingman'. This would allow these assets to be used with today's manned combat air platforms before Tempest is available. **AI**



Glitzy award ceremonies, black-tie dinners and lavish launches are part and parcel of airline chief executive officer life. However, when Australian-born James Hogan joined Etihad Airways as CEO in 2006, he started with a blank sheet of paper, sitting in a Portakabin parked on

the side of Abu Dhabi Airport.

Under Hogan's leadership, the fledgling airline grew from a \$300m business to a diversified travel and aviation group generating \$20bn annually. Along the way, it placed a \$43bn order for 205 new aircraft.

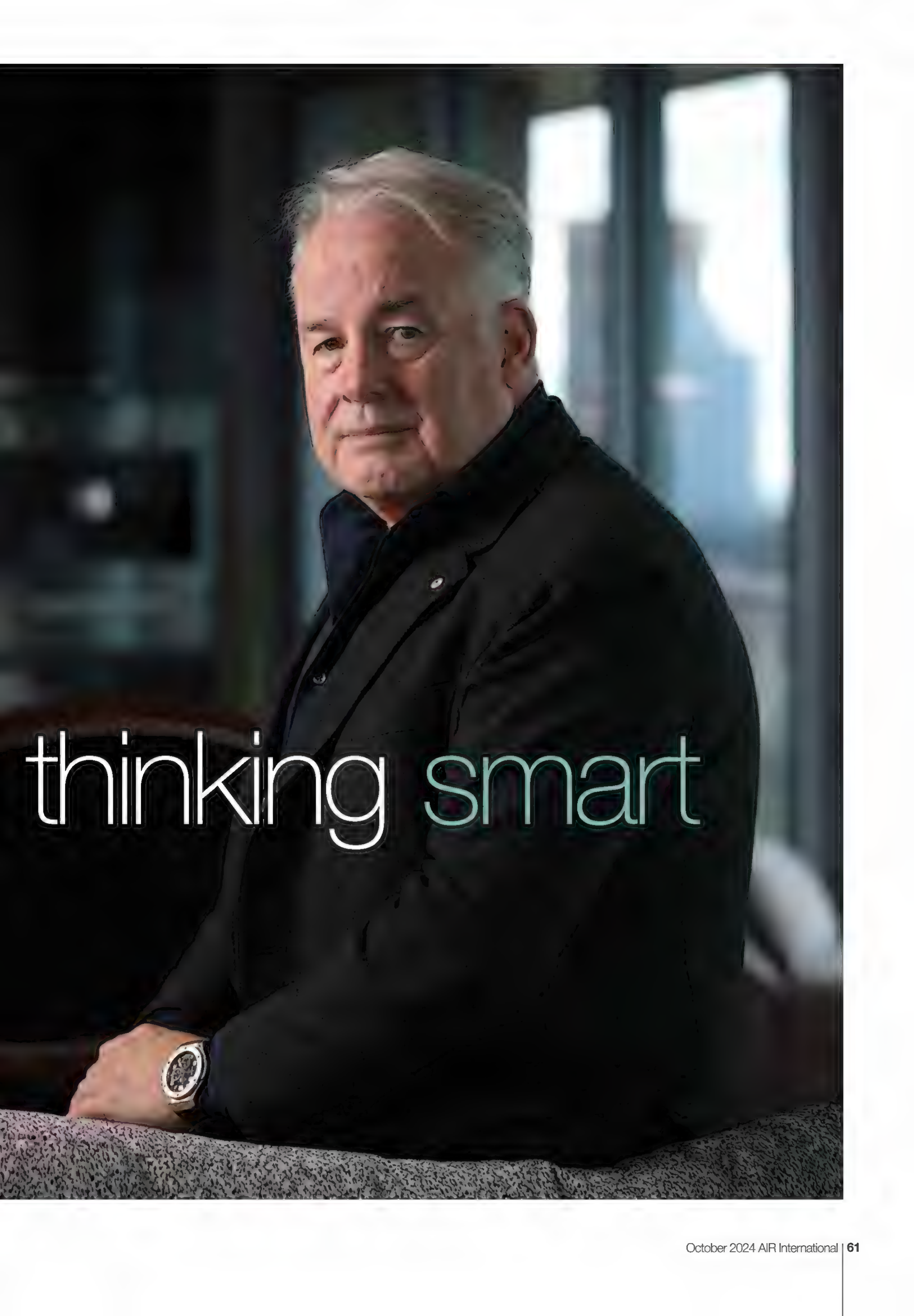
After leaving Etihad in 2017, Hogan formed Knighthood Global, a high-level advisory and consulting firm made up



Thinking positive,

After 11 years running Etihad Airways, former CEO James Hogan formed Knighthood Global and now tells **Michael Doran** about his new role advising airlines, airports, governments and the hospitality sector

James Hogan says Knighthood Global is there to "work closely with the board and management with a focus on the result"
Knighthood



thinking smart

of aviation experts with extensive hands-on experience in global aviation, working with airlines, airports, governments and the hospitality sector worldwide.

In August, Hogan made a quick visit to his hometown of Melbourne, Australia. While there, he generously agreed to chat with *Air International* about his time in the airline industry, about Knighthood Global, and the state of global aviation.

Hogan talked about Etihad and fulfilling the mandate from shareholders to support the Abu Dhabi Vision 2030. The Abu Dhabi leadership saw what Singapore and Dubai had achieved by developing their city as a destination in its own right, supported by airlines, airports, hotels and tourist attractions

The Vision was a driving factor for

Hogan and his team; a strategic plan to diversify the Emirate's economy away from oil and gas and develop new economic sectors, such as tourism, technology and manufacturing.

He said: "People don't realise that when I went to Etihad, we had nothing, and I started in a Portakabin on the side of Abu Dhabi Airport.

"We had to build everything, and most CEOs don't have to do that because they inherit the business, the brand and the infrastructure, but I had to do that from scratch."

After a successful stint as Gulf Air CEO, Hogan developed a keen understanding of aviation in the Middle East and the cross-cultural skills he needed to build a

cohesive workforce from more than 100 nationalities.

Under his mandate, a head office, engineering centre, IT facility and global brand were also to be built, plus the vital task of designing and implementing an airline strategy.

"If you took a three-hour ring from Abu Dhabi, you had the Gulf, the Middle East and the Indian sub-continent, which is a population as great as China, and people flying from Europe or the Americas didn't want to fly into hubs. So that meant we had one stop over the Gulf instead of going over London, then coming into another point and then to Bangalore or wherever."

He added that Gulf

Hogan wanted the A380 to be a significant step change for Etihad

Airbus



Airlines will fly to cities that other carriers shun and all through the region and across Africa. That was an opportune time to ask Hogan about the impact on mega-hubs from new, longer-range aircraft, such as the Airbus A321XLR and A350 XWB operating point-to-point.

He quickly dismissed that by pointing out that hubs in the Middle East are not dependent on traffic from Australia, that Europe is a mature market where airport slots are heavily constrained, and that the real opportunity lies closer to home.

"The key areas of opportunity are India, Pakistan and Bangladesh, which are huge markets in their own right. All the secondary cities in the Middle East, where you'll never see airlines fly into from Europe or America and all the emerging

secondary cities of Africa and China – that's the opportunity."

When starting at Etihad, Hogan had a clear vision for the airline to be "best in class". This vision was epitomised in 2008 when he signed one of the largest aircraft orders in history, for up to 205 new aircraft worth approximately \$43bn at list prices.

He told *Air International* his direction was that the new Airbus A380s and Boeing 787s would be a major step change for Etihad, which is why the unique Residence at Etihad Airways, a three-room suite in the sky, was born. The Residence features an ensuite shower room, a private bedroom with a double bed and a separate living area. "We looked at the space, and after we created

first class, business and economy, there was a corner space, so I said we can put a shower in there or a double bed and let's create something special that people will go 'Wow!'.

"From a customer perspective, the A380 is a great experience, but from an operational cost perspective and secondary market perspective, it's not the best return. We had cabin crew who were food and beverage managers, nannies especially trained to look after kids and a butler. It was a major step change, and I'm proud of what we achieved."

In his 11 years as CEO of Etihad, Hogan drove the airline to success. He had achieved the mandate of a competitive best-in-class airline, and Etihad





carried 18.6 million passengers annually, supporting close to 92,000 jobs.

When asked about his term at Etihad and what stood out, such as challenges or learning, Hogan paused then replied: "It was getting good people with the right skills who would become future leaders because, at the end of the day, it was Abu Dhabi's airline. My responsibility was to ensure that they had the future leadership and talent to build, and I am very proud of doing that."

In 2017, Hogan left Etihad. After 16 intense years running two airlines in the Gulf, he decided it was time for a change and to do something in his own right. That led to his current venture, Knighthood Global, which he set up in 2020 to offer business advisory, capital structuring and investment services in aerospace and aviation, travel and tourism, hospitality and real estate.

Hogan is chairman of Knighthood and was joined by fellow principal and CEO James Rigney – who was chief financial officer of the Etihad Aviation Group between October 2006 and June 2017. The team has an extensive list of aviation experts, partners and advisors who work with airlines, airports and

governments worldwide.

Despite being offered other airline opportunities in the Gulf and elsewhere, Hogan said that after putting his heart and soul into Etihad for 11 years, he had no desire to turn out in a different coat to fight his own creation: "It was time for a change, and I just thought that in establishing what I do, I could use my Rolodex and my skills and work at my own pace to do what I want to do and walk away or say no to what I don't want to do," he explained. "Which is a nice place to be."

Almost everything Knighthood does is confidential, and Hogan only let out a few snippets here and there, but it is very clear that the group is working on a wide variety of projects around the world, from airports in the Middle East to selling an airline in Europe and the rebirth of Air Malta into KM Malta Airlines.

While the projects are private, the work Hogan and his team of aviation experts and airline managers do is not. They work very closely with the board and management, with a sharp focus on the result.

"Our role is not to take over from management, but to coach management and inform the board to create strong

teamwork. What's important to me is that we bring our experience and ensure that when we walk away, there's a good plan in place, and the management is empowered to deliver. We're there to support them, not take over."

One project that can be discussed is the restructuring of Air Malta, which emerged in March this year as KM Malta Airlines, Malta's flag carrier. The airline was formerly government-owned, and Knighthood worked with the chairman and management for around three years on all aspects of the restructuring.

MAIN IMAGE:

Etihad is the largest 787 Dreamliner operator in the Middle East. The jet's lighter composite structure enables the airline to reduce fuel use and emissions. These aircraft are 20-30% more efficient than the in-service airliners they replace

Etihad

RIGHT:

For Etihad, the A380 serves as an excellent experience for passengers, but from an operating cost, it is not the best aircraft currently out there

Airbus



"We do considerable work in Africa where they see the opportunity of what aviation brings in creating jobs. One of the biggest challenges is the large population of under-30s who lack opportunity, and without opportunity, you have disruption. We did the restructuring plans for Air Zimbabwe with the World Bank and the other stakeholders, and now they have that plan, and it's up to them to implement it.

"So, we have airlines, we have airports, and we are just doing a deal with an African group to put some cargo aircraft

in," he said. "I work very closely with the head of Chinese airports under the Belt and Road initiative and lecture at Tianjin University."

While consumer demand remains high, many airlines are feeling the pinch as more capacity comes online and ticket prices soften. It is clear that 2024 is not looking as financially rosy as last year, so it was a good time to ask Hogan about the state of commercial aviation.

Unsurprisingly, he was upbeat about the future and points out that aviation has always been bedevilled by cycles,

whether internal or external, but there are parts of the world, such as India and Africa, that will continue to open up and create new opportunities: "There are immature airlines, youthful airlines and mature airlines and then there's regulation, bilateral status, geography and all that impacts the model," he explained. "The mature airlines, like British Airways, Lufthansa Group, United, American and Qantas, have their respected brands, infrastructure, talented people, routes and slots, giving them a major competitive edge."

Another major strength of mature airlines is their well-established loyalty programmes and strong alliance partnerships, especially how they use those to distribute fares, adding to their inherent competitive advantage. At the next level, Hogan talked about the Gulf airlines, the Chinese and Indian carriers and others like Turkish Airlines, which are still developing their own models.

While the Gulf carriers get most of the attention, Hogan said that European airlines face serious competition from Turkish Airlines, with eastbound traffic over Istanbul flying out of more European cities than the Gulf airlines.





“Africa and India will emerge, and China will accelerate, so the biggest challenge today is just how you navigate airports or slots”

James Hogan, CEO,
Knighthood Global

China is another developing region, and while there is a post-pandemic focus on domestic traffic, Hogan believes they will re-emerge internationally in the next few years.

“And I’ve always been very clear that I see India as a market that’s going to be a major player of the future, and in the next five years, the Indian airlines, like the Tata Group and IndiGo, will emerge as very strong players. We go back to population, segmentation, the worldwide Indian diaspora, and the large aircraft orders they are placing all point to that.

“Then you have got the developing countries of Africa and the Eastern European countries that currently rely on Wizz, which are both huge population markets, and the low-cost airline segment as well,” he added. “There’s high demand coming out of COVID, but we don’t have full capacity or aircraft availability, although that will change over

the next couple of years. For now, it’s a honeymoon period for all airlines.”

What’s not predictable are the external shocks that come along fairly regularly and, as the pandemic showed, can wreak havoc on the aviation industry. Hogan pointed to his time in the Middle East, where he had to deal with the impacts of the Iraq and Afghanistan wars, the SARS outbreak, volcanic ash disruptions, COVID-19 and now the emergence of another possible pandemic from the Monkeypox virus.

He added: “Africa and India will emerge, and China will accelerate, so the biggest challenge today is just how you navigate airports or slots, especially at certain European and US airports, as well as aircraft availability and talent. Where are the future pilots and engineers coming from; how do you manage your people; and how do you manage your customers.” **AI**

Knighthood Global has worked closely with restructured KM Malta Airlines
Airbus



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Working towards greener skies

A centuries-old technology could help with a very modern dilemma: creating a more sustainable aviation industry.

Alex Preston looks at some of the efforts to unlock the future of zero-emissions flight

“If we want to truly decarbonise aviation, we need to stop emitting CO₂ and other greenhouse gases at the tailpipe,” asserts Jenny Kavanagh, chief strategy officer at Cranfield Aerospace Solutions (CAeS) in Bedfordshire.

One option is electrifying aircraft directly, but Kavanagh cautions against this as a green panacea for all aircraft types: “Although batteries offer a more



energy-efficient zero-emissions solution, the energy density of batteries is 10% of kerosene and therefore, battery-only solutions tend to be very heavy to achieve the same amount of power," she said. "For very small training or recreational aircraft, that can be made to work, but for any commercial offering (aircraft of five seats or more), it's not a practical solution."

Try telling that to US-Israeli Eviation, whose all-electric nine-seater commuter aircraft, Alice, has recently completed testing at the University of Washington's Kirsten Wind Tunnel in Seattle. With more than 400 runs completed and almost 9,000 individual test data points, the data complement those gathered during Alice's first flight in 2022. Orders for Alice now exceed US\$5bn.

Another potential option, and one gaining significant traction, is hydrogen.

Green hydrogen

Many companies, including Airbus, have identified hydrogen as one of the most promising alternatives to powering a zero-emission aircraft. When generated from renewable energy, hydrogen emits no carbon dioxide, and water is its most significant by-product.

"Hydrogen," said Kavanagh, "has three times the energy of kerosene per kg, so although the storage of hydrogen and the propulsive systems are heavier than current fossil fuel-based solutions, they offer a significant advantage over battery-only technology."

There are two routes to using hydrogen for aircraft propulsion. One is hydrogen combustion in a gas turbine, while the second is fuel cells converting hydrogen into electricity to power a propeller engine.

In fuel cells, hydrogen reacts with oxygen to produce electricity, powering electric motors that drive the aircraft propeller.

Dr Nathalie Duquesne, managing director at Liebherr-Aerospace Toulouse SAS in France, said: "Fuel cell systems

are a promising technology in the aviation industry because they reduce carbon emissions and increase energy efficiency."

Fuel cells are more efficient than combustion engines, so they use less fuel than if you burned the hydrogen. According to Duquesne, they can convert up to 60% of the energy in the fuel into electricity, much higher than conventional combustion-based technologies.

Burning hydrogen, said Kavanagh, also produces nitrous oxides in addition to the water due to the high temperatures involved, "so it is not as clean a solution (but far better than kerosene)," she added.

Another benefit of hydrogen fuel cells is that they generate less noise than traditional aircraft engines, potentially resulting in quieter flights.

"It's worth noting that the hydrogen fuel cells are not new technology," observed Kavanagh. "They have been around since the 1800s. The challenge we have is developing them for aerospace, making them small enough and light enough to be a commercially viable product and ensuring that they are designed as a system to meet the stringent safety requirements of aerospace."

Ongoing evaluation

Significant research and development have been conducted in fuel cell systems in recent years, including advancements in fuel cell materials, stack design and system integration.

Airbus has been exploring the possibilities of fuel cell propulsion systems for aviation for several years. In late-2020, Airbus and automotive supplier ElringKlinger founded a joint venture, Aerostack, to research, develop and assemble fuel cell stacks for future aeronautic applications.

As Airbus explained, it does not release much energy because one single fuel cell is only a few millimetres thick and roughly the size of a letter envelope. Therefore, to

PREVIOUS PAGES:

Airbus is one of the many companies exploring the potential to commercialise hydrogen fuel cells for passenger aircraft

Airbus/Hervé Goussé - Master Films

CLOCKWISE FROM TOP RIGHT:

Project FRESSON, a collaboration between Reaction Engines and Cranfield Aerospace Solutions, addresses a critical obstacle in the journey toward hydrogen-electric flight: thermal management

CAeS

Liebherr-Aerospace has installed a hydrogen bench in its test centre at its Toulouse site

Liebherr

CAeS is converting a Britten-Norman Islander nine-seat aircraft from conventional fossil fuel to that of gaseous hydrogen propulsion

CAeS





realise sufficient power levels for use in an aircraft, hundreds of these fuel cells need to be electrically connected in series to form a 'stack'. Subsequently, several such stacks are combined into multiple fuel cell 'channels'. With this modular approach, the megawatt power levels needed for an electric aircraft are achievable.

Aerostack is an independent competence centre that develops and validates aviation-compatible hydrogen fuel cell stacks and their complete lifecycle management. It has two sites in Dettingen/Erms (south of Stuttgart, Germany) and Taufkirchen (Munich area, Germany).

The joint venture is a key driving force behind Airbus's ZEROe programme, which aims to develop the world's first hydrogen-powered commercial aircraft by 2035.

Already the company has completed a series of significant milestones. In June 2023, Airbus announced the successful test campaign of the hydrogen fuel cell system (using 12 fuel cells coupled together on a single propeller), which reached its full-power level of 1.2MW – claimed to be the most powerful test ever achieved in aviation of a fuel cell designed for large-scale aircraft. Months later, the powertrain was tested at 1MW, before closing the year with the electric motors of the iron pod powered with the hydrogen fuel cells for the first time.

Hauke Peer-Luedders, head of fuel cell propulsion system for ZEROe, said such a testing structure allows the team to "measure how the propulsion system as a whole works by testing the power needed

for several different flight phases, such as take-off, where we are reaching maximum power levels, and cruising when we use less power but over a longer period of time".

The ZEROe programme is supported by ElringKlinger's joint venture with Plastic Omnium, EKPO. This venture developed the NM12 stack technology, which serves as the programme's baseline platform for the development of bespoke aerospace products.

According to EKPO, the NM12 stack family is the most powerful in its portfolio, with an output of up to 205kW_{el} and benchmark power density above 6.0kW/l. "The scalable and modular stack design offers the best possible basis to suit a wide range of applications with maximum flexibility and efficiency. This platform

was the ideal starting point to address the unique performance expectations of aviation,” the company reported.

Liebherr-Aerospace began researching fuel cell systems more than 20 years ago for automotive applications with a turbo charger. It said there has been growing interest in the aviation industry for this technology, and is actively working to improve the efficiency, durability and performance of these systems.

Duquesne described how, in early 2020, Liebherr started research activities for aerospace applications, culminating in developing a hydrogen-powered test bench to evaluate fuel cell systems performance. “This test bench was inaugurated in Toulouse in 2022. Now, the company aims to design and qualify a safety-of-flight air supply demonstrator that can withstand the integration constraints in an operational environment close to the propulsion system.”

This demonstrator will support Airbus’s ZEROe flight test campaign to demonstrate the performance of a fuel cell propulsion system under operational conditions by the middle of the decade. She continued: “This would be a major step towards the development of a decarbonised aviation industry, as the air conditioning system accounts for a significant portion of the aircraft’s energy consumption.”

Cranfield Aerospace Solutions is currently developing a 250kW hydrogen propulsion system under the auspices of Project Fresson. Its first application is the Britten-Norman Islander aircraft, an existing nine-seat aircraft that will be modified to take the new CAeS drivetrain. However, the Islander is one route to market.

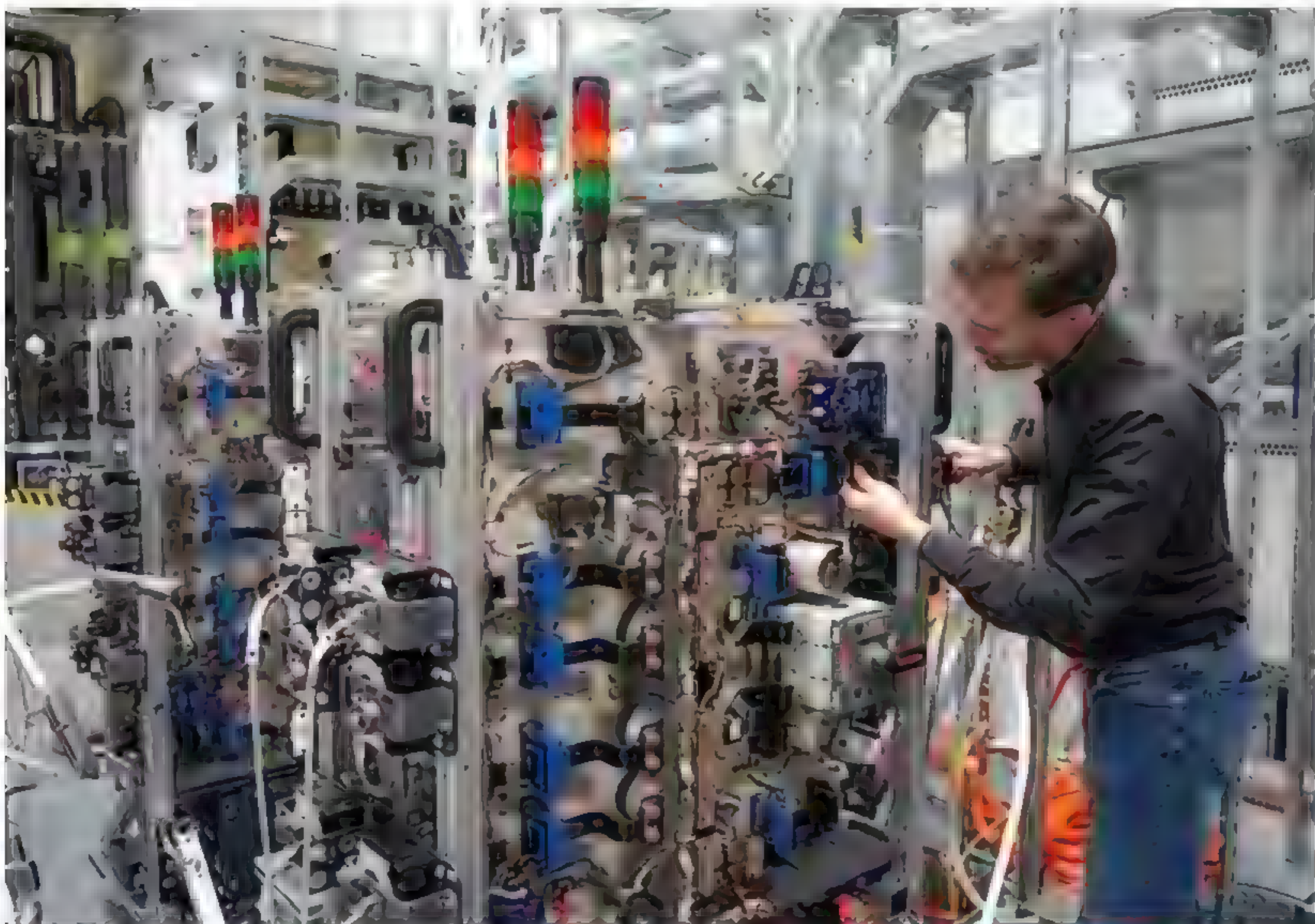
The hydrogen fuel distribution and tank system deliver hydrogen fuel in gaseous form to the hydrogen fuel cell system. The hydrogen fuel cell systems consist of the

RIGHT:
While not modern, hydrogen fuel cell technology power alternative-propulsion systems are still new to aviation

Airbus/Hervé Goussé - Master Films

BELOW:
The EKPO fuel cell system was tested at the EAS Test House, Europe’s largest test facility dedicated exclusively to alternative propulsion systems and fuels

Airbus



“There are two routes to using hydrogen for aircraft propulsion. One is hydrogen combustion in a gas turbine, while the second is fuel cells converting hydrogen into electricity”

HFCS Balance of Plant (BoP), an electric motor, inverter and controllers, a pitch control unit and all the HFCS’s electrical cabling, routing and cooling systems. The 240kW HFCS system in each nacelle provides power to the electrical propulsion unit, with an output shaft power of 220kW. This powers the three-blade propeller at 2,300rpm.

Hydrogen propulsion systems that are in development at CAeS are designed to be scalable and adaptable to multiple applications, including eVTOLs, cargo UAVs, seaplanes and amphibious vehicles, airships and auxiliary power units in large commercial aircraft.

Kavanagh said: “With a demonstrator flight expected in 2025, we are targeting certification of the product version of the modification in 2026 with the aim to have it in commercial service from 2027.



"If, as an industry and a country, we are to succeed in delivering zero emission aircraft into passenger service, it is vital that the regulation and infrastructure evolve hand-in-hand with emerging technologies such as CAeS's hydrogen propulsion systems."

Many hands

CAeS is part of a consortium called the Sustainable Aviation Test Environment (SATE) based in Scotland, which brings together 13 partners from across the eco-system, from operators, research institutions, energy providers and technology developers like CAeS to show emerging technologies along with real-world potential scenarios. "Our focus from this consortium is on the Islander operations in Orkney, but the outcome of this collaboration will benefit the whole

industry," said Kavanagh.

Liebherr-Aerospace Toulouse is collaborating with various partners, including universities, research institutions and industry partners to advance the research and development of fuel cell systems. The company is participating in the European research project Clean Aviation and are also supported by the French Civil Aviation Authority (DGAC). "The installation of the test bench in our facility in Toulouse was supported locally by the Région Occitanie," said Duquesne.

Collaboration is also taking place with those outside the aviation industry. For example, since 2021, Liebherr-Aerospace Toulouse has been working with General Motors (GM) to develop an integrated fuel cell system, customised to the performance and economic requirements of commercial aircraft. The two



have developed a fuel cell system demonstrator, called Main Electrical Power System (MEPS), including fuel cell stacks based on GM's HYDROTEC power cube and fuel cell technology. MEPS has been tested since the second quarter of 2023. At the beginning of this year, Liebherr was able to demonstrate power supply for its developed electrical environmental control system (eECS) with the help of the fuel cell system.

Speaking at the time of the partnership announcement, GM executive director – Global HYDROTEC, Charlie Freese, said: "Aircraft are a great litmus test for the strength and versatility of our HYDROTEC fuel cells. Our technology can address customer needs in a wide range of uses – on land, sea, air or rail, and this collaboration with Liebherr could open up new possibilities for aircraft, transitioning to alternative energy power sources."

Overcoming obstacles

Liebherr-Aerospace's Duquesne admitted that while there are still some technical and economic challenges to overcome in the development of fuel cell systems, the supporting infrastructure is growing. CAes's Kavanagh explained: "Of course, there are numerous challenges in developing and certifying novel aviation technology, but three of the major challenges CAes has identified and is solving are the packaging of the technology, the thermal management and standards and regulations."

Despite successfully designing the integration of a hydrogen fuel cell system into the nacelle of the Britten-Norman Islander aircraft, packaging was a significant

challenge for the team, as the space within the nacelle is extremely limited, making it very difficult to find an effective solution that meets all the stringent safety requirements set by themselves.

"By doing this, we have identified all the key technical and packaging challenges of designing a safe and efficient hydrogen power train and found solutions for them all, ready for when we go to certify the product version," Kavanagh explained.

The next major challenge for the team was thermal management. Kavanagh said traditional aircraft powertrains typically use hot exhaust gas streams to dissipate most of their waste heat, contrasting the thermal management requirements of fuel cell-powered aircraft.

Hydrogen fuel cells necessitate the rejection of significant amounts of low-grade heat, presenting a unique engineering challenge. Using conventional methods for this heat rejection from hydrogen fuel cells would result in large, heavy heat exchangers, imposing mass and drag penalties compromising aircraft range and performance.

Central to the project's success is adopting annular microtube radiators, a game-changing thermal management technology developed by Reaction Engines. These radiators, which use mixed counter-crossflow to maximise efficiency, represent a shift in heat exchanger architecture.

A cutting-edge microtube heat exchanger can cool air from 1,000°C to -150°C in 1/20th of a second.

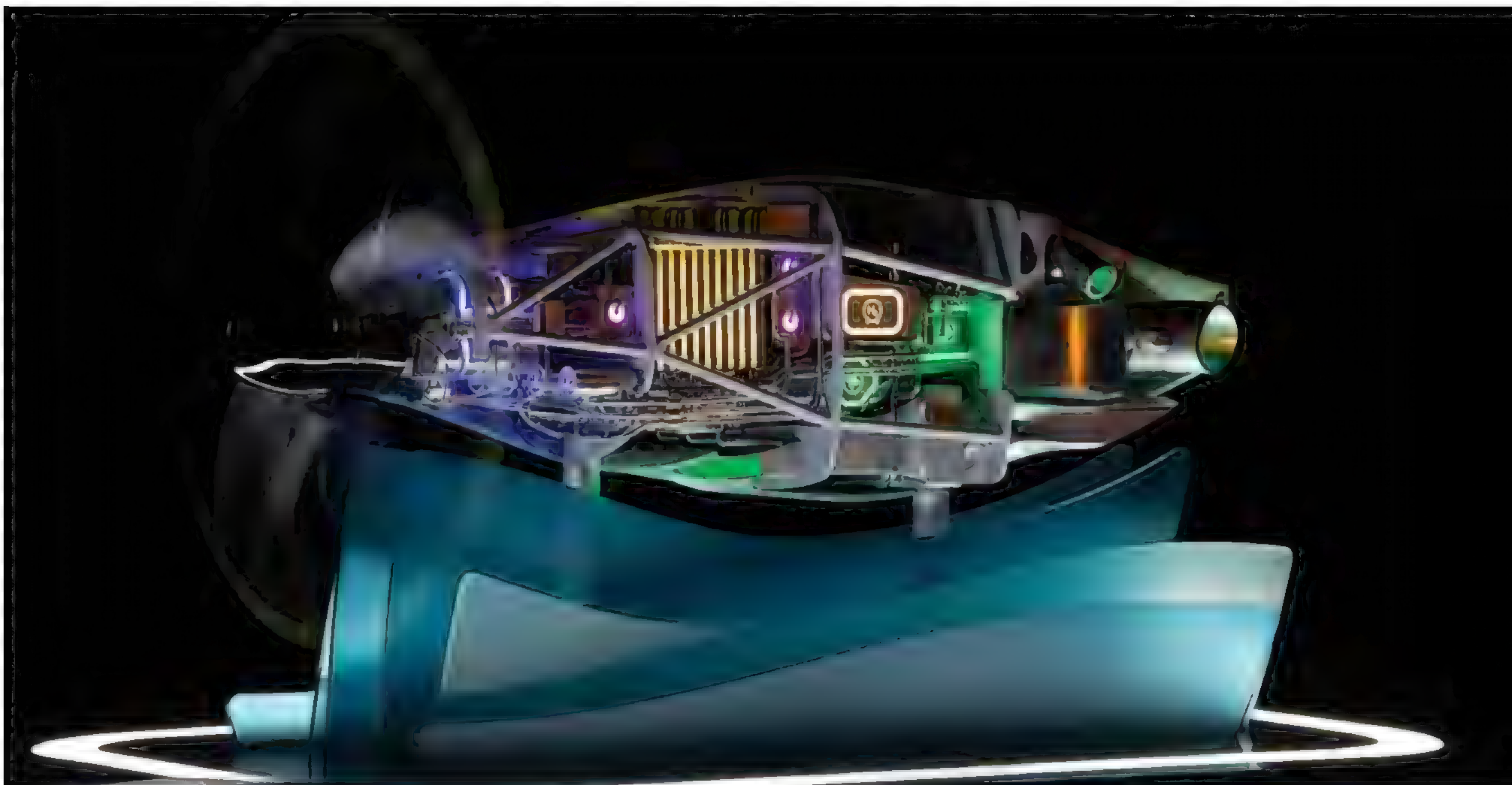
Kathryn Evans, Applied Technologies Aerospace lead at Reaction Engines, explained how the heat exchanger

CLOCKWISE FROM TOP RIGHT:

A modified A380 will enter service by 2035 powered by hydrogen fuel cell engines
Airbus/Hervé Goussé - Master Films

General Motors (GM) and Liebherr-Aerospace have joined forces to develop a hydrogen fuel cell-based demonstrator system for aircraft based on GM's HYDROTEC technology
Steve Fecht/General Motors

Airbus is developing a hydrogen-powered fuel cell engine to equip its zero-emission (ZEROe) aircraft
Airbus/Hervé Goussé - Master Films





incorporates thousands of millimetre-scale tubes – made from hair-width materials and arranged in a spiral design. The result is incredibly high levels of heat transfer – as high as 99% effective cooling – within a much smaller and lighter device.

The collaboration has resulted in a lightweight, efficient radiator capable of rejecting more than 300kW of low-grade waste heat while minimising mass and drag penalties.

The company claims that by applying this technology to fuel cells, it can solve the thermal management problem that could otherwise keep hydrogen fuel cell aeroplanes grounded. “It has been recognised by our partners as a genuinely ‘enabling technology’,” explained Evans. “It will be critical to getting hydrogen fuel cell planes off the ground.”

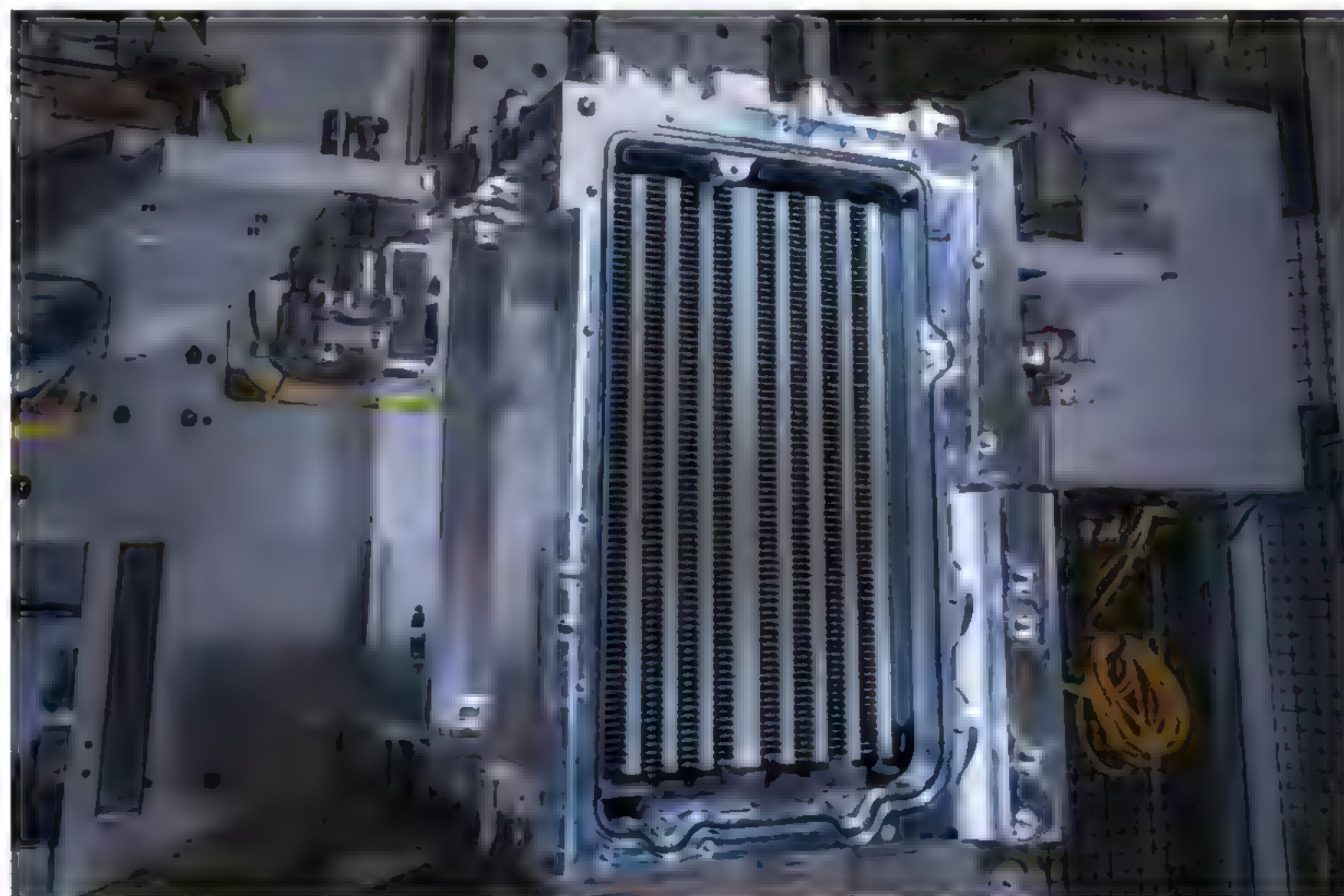
Finally, standards and regulations for novel technology is a significant challenge. Regulators like the CAA are becoming increasingly engaged with new and sustainable propulsion technologies for aviation, with hydrogen and electrification being high on the agenda at the moment, said Kavanagh: “However, there are big gaps in current standards and regulations for hydrogen, so a focus for us is to work with regulators like the CAA to identify these gaps and look at the inherent risks of hydrogen and high voltage on aircraft applications.

“We need to work collaboratively with the CAA to define a set of requirements to demonstrate that our aircraft is safe to fly. This year, CAeS was one of the first three organisations selected for the CAA’s Hydrogen Challenge Sandbox; the aim of which is to increase industry and

regulatory readiness for the introduction of hydrogen fuel and new technologies.”

At the beginning of 2023, a consortium including Honeywell and Reaction Engines launched a European Clean Aviation project that aims to develop a new generation of hydrogen fuel cells for the aviation industry. Project NEWBORN will involve multidisciplinary collaboration between 18 partners from ten European countries to develop an aerospace-qualified megawatt-class fuel cell propulsion system powered by hydrogen.

The megawatt-class fuel cell propulsion system delivered by NEWBORN will create future, sustainable aviation beyond a megawatt. Pipistrel Vertical Solutions, a Slovenia-based disruptive general





ABOVE:
Cranfield Aerospace Solutions has successfully designed the integration of the hydrogen fuel cell system (HFCS) and electric propulsion unit (EPU) within the nacelle of the Islander aircraft
CAeS

BOTTOM:
The bipolar plate, the core element of a fuel cell stack, regulates the supply of hydrogen and air and the removal of water
ElringKlinger AG

aviation manufacturer, will integrate and test the final demonstrator.

Axel Krein, executive director of Clean Aviation on the programme's inauguration, said: "Achieving aviation's transformation to climate-neutral requires a comprehensive arsenal of disruptive solutions that will bring momentous gains in aircraft energy efficiency coupled with low or zero-carbon energy sources. With the launch of NEWBORN we can kick-start the necessary work to drive a step change in aircraft performance and deliver EU Green Deal ambitions for net-zero flight."

Research projects

Such ambitions are being supported by the Advanced Fuel Cell for Aviation Decarbonisation (AFCAD) project, which involves a collaboration between ZeroAvia, the University of Kent, Coventry University and the University of Sheffield Advanced Manufacturing Research Centre.

FCAD builds on ZeroAvia's successful HyFlyer I and II ATI projects, which have delivered the first flights of hydrogen-electric aircraft and demonstrated the largest High-Temperature Proton Exchange Membrane (HTPEM) fuel cell technology.

The HTPEM stack module for aviation shows technology readiness for scaling fuel cells into large commercial aircraft. ZeroAvia sees HTPEM fuel cell power generation as key to developing zero-emission propulsion systems for aircraft larger than 20 seats, and the technology is integral to the company's ZA2000 2-5.4 MW engine for 40-80 seat aeroplanes.

"Of course, it's not all about the aircraft technology," said Kavanagh. "The ultimate challenge is that not only are we working on transformational technology, the like of which the industry has not seen since the advent of the Jet Age, but the new technology also brings with it the need to change the entire aviation ecosystem – the aircraft, airport operations, maintenance operations, refuelling and end-to-end safety and quality management based on an entirely new fuel.

"This presents the ultimate challenge, but we must not forget that we're doing this in the context of a global energy transition," she added. "We are not alone and, to a large extent, the global drive towards a more sustainable future will help ensure the infrastructure for this new technology. Aviation will require significant amounts of hydrogen (estimated to be about 20 million tonnes annually by 2050 for direct use in aircraft).

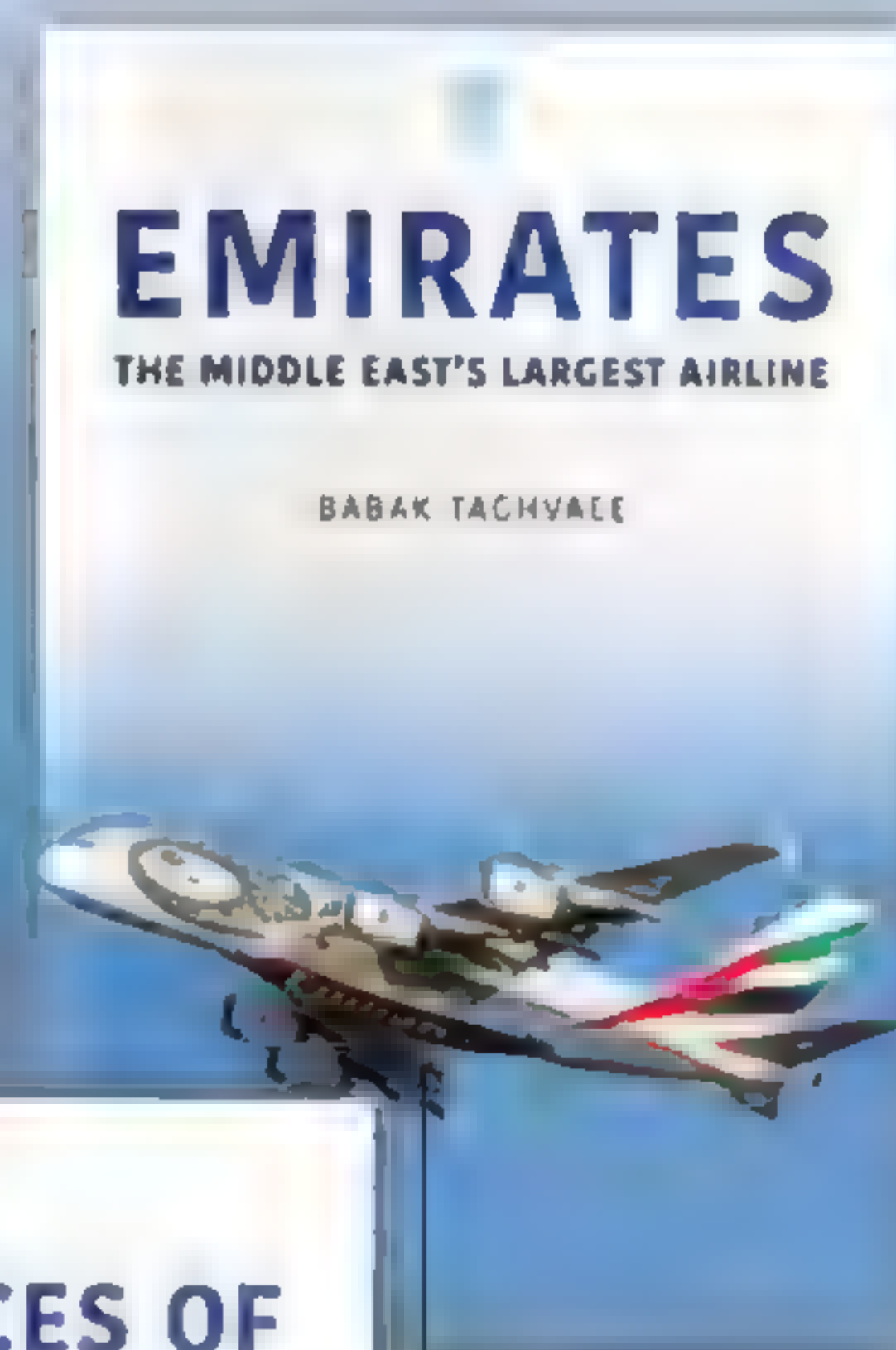
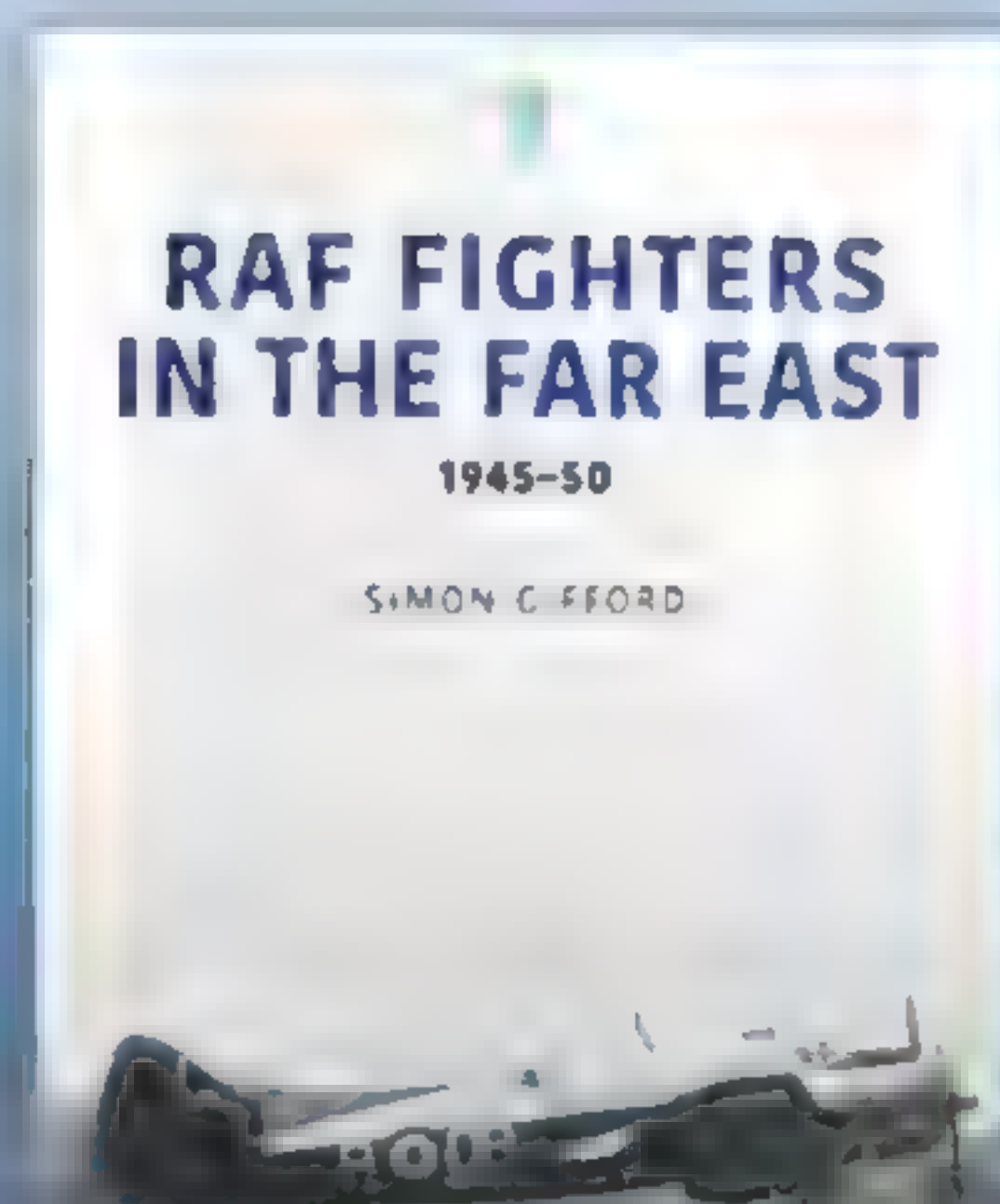
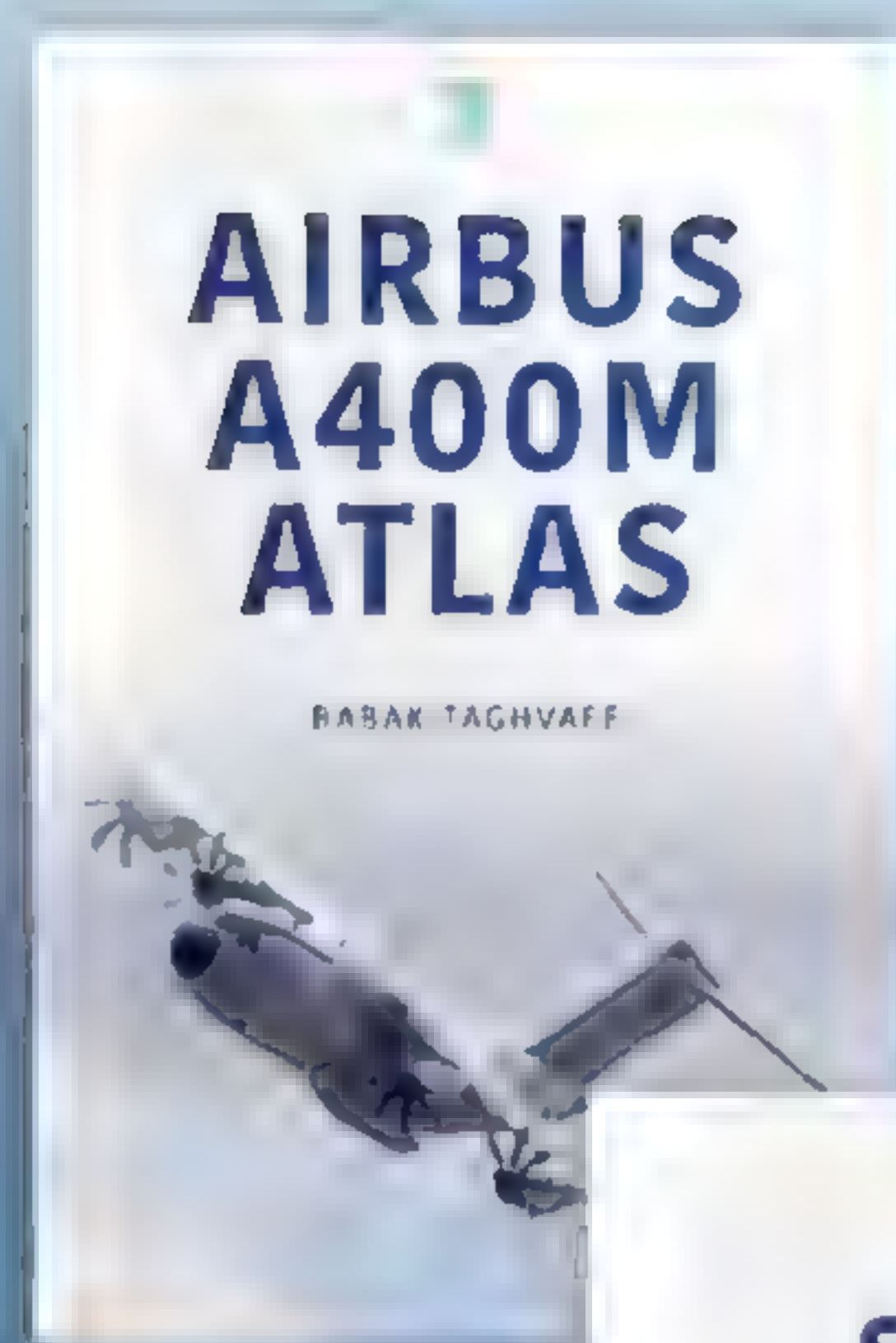
"Still, at least at the start, the demand will be driven by other industries – we are already seeing this happen with road transportation, the food and drink industry, glass and chemical production. Is the infrastructure there yet? No – but it's coming, and the UK and Europe are leading the way." **AI**





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Eight Questions

AMETEK MRO is a global provider of third-party MRO services to the commercial, regional, general aviation and defence sectors.

Mike Audus, divisional VP and business unit manager, Aerospace Europe, AMETEK MRO, spoke with *Air International*

Question 1: How has the MRO sector changed in the last five years? What business practices have been adopted and learned from the COVID-19 pandemic?

The last five years have seen significant changes across all aspects of the aviation industry, affecting AMETEK MRO's facilities worldwide. The pandemic meant that everyone downsized operations, but now, with the pandemic over and global traffic reaching new norms, I would say the biggest change has been spooling up to support new levels of activity across the board. This comes primarily in the form of people and parts.

From a people point of view, encouraging technicians and engineers back to the industry has been more challenging than anticipated, and even getting people back into offices presents a long-term challenge.

From a parts perspective, we see operators continuing to use legacy aircraft for much longer than predicted, as the aircraft OEMs cite supply chain issues as the primary cause of delayed deliveries of new aircraft. These supply chain problems are also impacting specialist component OEMs, creating a knock-on effect that means we have to wait longer for parts. Fortunately, we have specialist teams and planners that anticipate parts requirements and enable us to maximise efficiency and sustain our repair turnaround times. I see many people looking at their inventory and forecasting material needs quite differently, and the use of digital and AI tools will continue to grow in this space to manage the right levels better.

At AMETEK MRO's facilities in the United Kingdom – Muirhead Avionics, Avtech and AEM – and our operations in France

– ANTAVIA – the flow of repairs for older components to match the ageing global fleet's ongoing performance to sustain operational demand is steadily increasing.

Question 2: AMETEK MRO has 12 strategically placed locations around the globe. Where are these and why were they selected? Are there any specific regional differences/challenges that you have to overcome?

We have facilities in the US, Europe and Singapore that enable us to provide global services to our customers, many of whom require specialist repair capabilities underpinned by the investment, technical calibre and intensive product knowledge that AMETEK MRO brands can provide. As an international business with decades of experience behind us, we are accustomed to a plethora of varied working practices and differing skill sets. Any challenge has a solution.

Experienced teams from ANTAVIA in France recently set up a new wheel and brake shop in Singapore, for example, training the local workforce to meet the standards of quality and speed expected. Muirhead Avionics just moved to new premises close to London LHR and almost immediately amalgamated with Avtech, which closed its facility in Miami. This knowledge-sharing, equipment integration and process streamlining is only possible with a global mindset that recognises and respects local differences.

AMETEK MRO's facilities tend to be near significant airports such as Paris Charles De Gaulle or London Heathrow. This is useful for logistical reasons when we ship repaired parts worldwide, but it is essential when we support AOGs, which are typically time-critical events. As a

business, we continually look to expand into other parts of the world and closely watch the evolving MRO environment, ensuring we have the agility, market intelligence and insight to maximise opportunities.

Question 3: What support do you provide to the defence sector? Have you seen increased work, given the tensions in Europe and Asia? If so, what work are you undertaking and what are the challenges compared to supporting the commercial sector?

We do some work for military OEMs and end users based on our in-house capability or through repair management. Due to the current geopolitical situation, we can see more work coming in, especially in our wheels and brakes shops and our repair management business. The main challenge is to tackle obsolescence on spares for legacy platforms. Our presence in the UK and France offers a national solution for defence partners that must comply with a 'buy local' policy. AMETEK MRO also recruits ex-military technicians to our avionics businesses. These people have excellent training and the mindset to thrive in the MRO sector.

Question 4: AMETEK MRO supports some of the largest helicopter manufacturers in the world, including Bell Textron, Sikorsky Aircraft, Leonardo Helicopters and Airbus Helicopters. Given the vast number of roles these aircraft perform and, at times, their remote operating locations, can you explain the process of providing help to an operator at a remote location and how the matter is resolved?

First and foremost, AMETEK MRO offers AOG support for the equipment on our capability lists. This will always aim to get customers out of any urgent support situation wherever they are located. Our logistical teams are well-trained to cope with urgent and critical demands via our trusted network worldwide. Beyond that, we continue establishing relationships and capability to support their operations. If we can help them forward-plan for MRO events, it will help lessen risk and avoid unforeseen difficulties in remote areas. Helicopter operators who carry out emergency missions know they can rely on AEM and ANTAVIA because we understand their service imperatives.

risky at a piece part or test equipment level. Still, we continually look to source items that de-risk our operations, thus extending our ability to provide support. Sometimes, we work directly with the aircraft or equipment OEM to replace obsolete or hard-to-get components with newer available variants. This keeps the component assembly in service and significantly reduces the operator's cost.

Our workforce comprises engineers of all ages, and skills transfer is fundamental in our everyday capacity. It is extremely rare for any component to arrive with a fault or damage that we have not seen before, so our younger team members know they can always ask for advice on best practices. As aircraft evolve with new materials and systems, AMETEK MRO's people will grow, too, and our close partnerships with the OEMs mean that, as approved repair providers, it is in their interest to ensure specialist training is provided.

For now, we are renowned for our work on legacy types. The throughput of repairs at our facilities for the foreseeable future means that even our newest recruits and apprentices are fully trained on this older equipment.

OPPOSITE:

AMETEK MRO performs comprehensive overhaul services on thousands of parts; restoring the units to near-perfect condition
All images via AMETEK MRO

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Calibration testing plays a critical role at AMETEK MRO both in sourcing the initial problem with the part and, once repaired, in testing before redelivery to the operator

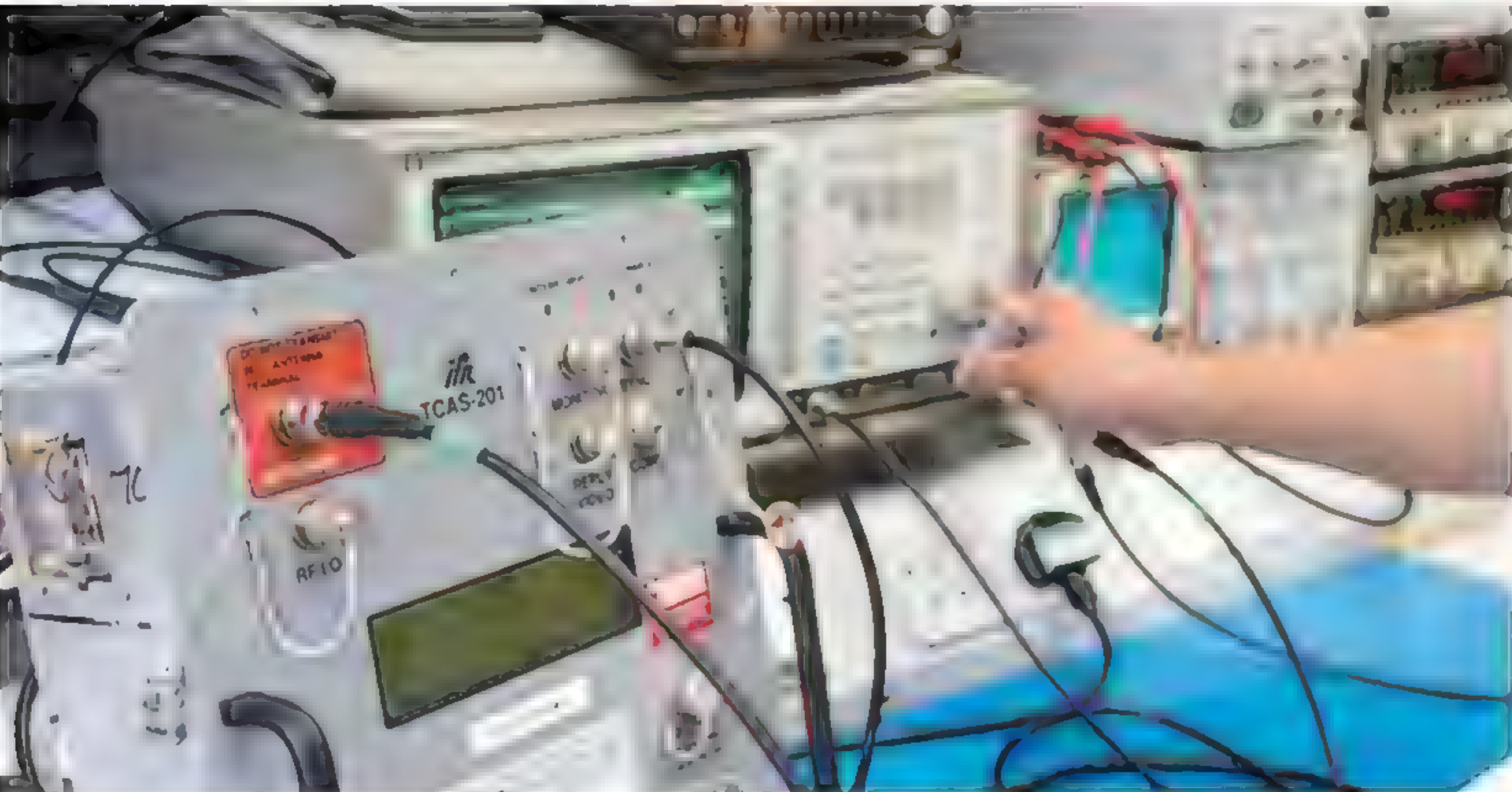
Helicopter oxygen bottles under test before being signed off and fit for use

One of the main undercarriage legs from an airliner undergoes inspection at one of the specialised bench set-ups used by AMETEK MRO

Wheel and brake repair has been a cornerstone of MRO work for many years

Question 5: Many operators are keeping their aircraft far longer in service than predicted. How has AMETEK MRO met this challenge and is ensuring that these old skills remain current across its workforce and continue to be taught, and how long will you continue such practices?

This means ensuring we have the right skills, parts and equipment to sustain our support, which is undoubtedly challenging. Obsolescence will always be



Question 6: Looking towards the future, how do you see the MRO industry in ten to 15 years? What does it need to remain a viable, profitable industry? Do governments need to provide help?

Partnering is vital, be that with customers or suppliers. Through good partnering, you can share information and make the right risk-based calls to ensure operations continue as long as needed. System architecture and the mix of products requiring support have clearly changed over the years, meaning the industry must adapt.

Both businesses and governments need to keep investing for the future, and apprenticeship programmes are an excellent example of this. We need to generate curiosity early through STEM programmes and apprenticeships to pull people into what is an exciting industry. The STEM approach to learning and development integrates the areas of science, technology, engineering, and mathematics, which are all important to the MRO industry. However, career development at AMETEK MRO facilities also stimulates students to develop key skills, including problem-solving, creativity and critical analysis. We want to train our people to become trainers in 15 years.

Question 7: The business jet market has seen a steady growth of types, many of which utilise new technology and materials. Looking ahead, how is AMETEK MRO preparing and supporting this evolving sector?

AMETEK MRO currently supports all major aircraft manufacturers and provides a high-quality service thanks to its well-trained, experienced and dedicated teams and its locations close to major hubs such as Paris Le Bourget and London Heathrow and Stansted. Our customers value AMETEK MRO's expertise, and we pride ourselves on underwriting OEM quality, so we work hard to ensure they select us when their new programmes enter service.

We offer wheel and brake repairs to business jet operators in France and Singapore. This rapidly growing service relies on flexibility, speed, and efficiency.

We are always excited by developments in the business jet market, whether they involve implementing new power technologies, creative applications of innovative materials or advances in avionics. These are often the forerunners of mainstream changes in the commercial aircraft sector.

Question 8: On a personal level, how do you spend your free time? Any hobbies that you enjoy?

I still love to travel, but business and vacation travel are quite different. I take

“Due to the current geopolitical situation, we can see more work coming in, especially in our wheels and brakes shops and our repair management business”

Mike Audus, divisional VP and business unit manager, Aerospace Europe, AMETEK MRO



any chance to visit a new country and experience something I have never done before. I love to ski/snowboard, which typically means a winter trip somewhere. I'm not particularly good at sitting still in a resort or on a beach, so summer vacations need to keep me engaged. Beyond that, I love to cook, so tasting new cuisine in different countries allows me to practice recreating it when I get home – often quite badly! **AI**

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Nine years after the development of South Korea's KF-21 Boramae began, the government signed a deal with KAI to produce 20 fighters MBDA

Next Month

New kid on the block The A321XLR will enter service soon. Mark Broadbent asks what capabilities the new long-range twinjet will bring to its operators

The next fighter? Jack Richardson looks into the history, design, and future of the Korea Aerospace Industries KF-21 Boramae. Could this 4.5-generation fighter upset the international combat aircraft market?

Beautiful disruptor The latest configuration of the Eviation Alice is confirmed. Bernie Baldwin spoke to the company's CEO, Andre Stein, on what's ahead

Racing ahead The Airbus Racer is a high-speed helicopter demonstrator that aims to leverage increased speed to offer a safe, proven aerodynamic formula, marrying speed, cost-efficiency, and mission performance



The A321XLR can comfortably carry up to 220 passengers on routes up to 4,700nm while burning 30% less fuel than previous-generation aircraft Airbus



The Racer builds upon the success of Airbus Helicopters' X3 demonstrator, that combines a traditional main rotor and innovative lateral rotors Airbus Helicopters

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